FINAL
Phase 2 Remedial Investigation Work Plan

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Operable Unit 1
700 South 1600 East PCE Plume Site
Salt Lake City, Utah

U.S. Army Corps of Engineers
Kansas City District

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System

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CDM Smith

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Phase 2 Remedial Investigation Work Plan, Version 0

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Acronyms and Abbreviations

AOU1	Accelerated Operable Unit 1
APP	accident prevention plan
bgs	below ground surface
CDM Smith	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CH2M	CH2M Hill, Inc.
cis-1,2-DCE	cis-1,2-dichloroethylene
CCC	criterion continuous concentration
CMC	criterion maximum concentration
COC	chain of custody
COPC	contaminant of potential concern
CSIA	compound-specific isotope analysis
CSM	conceptual site model
CQCP	contractor quality control plan
DMP	data management plan
DQO	data quality objective
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ER	engineering regulation
ESS	East Side Springs
FSP	field sampling plan
GIS	geographic information system
HHRA	human health risk assessment
HRS	Hazard Ranking System
IDW	investigation-derived waste
ITRC	Interstate Technology and Regulatory Council
MCL	maximum contaminant level
MFM	minor field modification
MS	matrix spike
MSD	matrix spike duplicate
NAWQC	National Ambient Water Quality Criteria
NPL	National Priorities List
OU	operable unit
PA	preliminary assessment
PCE	tetrachloroethene
PID	photoionization detector
PM	Project Manager
PVC	polyvinyl chloride
RPM	Remedial Project Manager
TCE	trichloroethene
QA	quality assurance
QAM	quality assurance manager
QAPP	quality assurance project plan

QC	quality control
RI	remedial investigation
RIWP	remedial investigation work plan
RL	reporting limit
RSL	regional screening level
SI	site inspection
Site	700 South 1600 East PCE Plume site
SLC-18	Salt Lake City Department of Public Utilities drinking water well no. 18
SLERA	screening-level ecological risk assessment
SOP	standard operating procedure
TCRA	time-critical removal action
UDEQ	Utah Department of Environmental Quality
USACE	U.S. Army Corps of Engineers
USACE-KC	U.S. Army Corps of Engineers, Kansas City District
VA	U.S. Department of Veterans Affairs
VAMC	George E. Wahlen Veterans Affairs Medical Center
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound
ZIST	zone isolation sampling technology
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
3D	three dimensional

Section 1

Introduction

Under U.S. Army Corps of Engineers, Kansas City District (USACE-KC) Contract No. W912DQ-18-D-3008, Task Order No. W912DQ19F3048, CDM Federal Programs Corporation (CDM Smith) was directed to perform Phase 2 of the remedial investigation (RI) for Operable Unit (OU) 1 of the 700 South 1600 East Tetrachloroethene Plume site (Site) located near the George E. Wahlen Veterans Affairs Medical Center (VAMC), in Salt Lake City, Utah. The U.S. Department of Veterans Affairs (VA) operated a part-time dry cleaning operation that used tetrachloroethene (PCE) over a 6-year period in the late 1970s and early 1980s. During this period, dry cleaning residuals were disposed of into the sanitary sewer. PCE-contaminated groundwater is present beneath the VAMC property and in areas hydraulically downgradient, extending to the East Side Springs (ESS) neighborhood.

Phase 1 of the RI was initiated at the Site in 2018 and is currently planned for completion in summer 2020. Phase 1 investigation activities included installation of shallow and deep monitoring wells within the source area and downgradient groundwater plume (including the ESS area), source area soil gas and soil sampling, aquifer slug and pumping tests, geophysical logging, geotechnical sample collection, groundwater sampling of new and existing monitoring wells, and surface water sampling in the ESS area and along Red Butte Creek.

Data collected during Phase 2 of the RI are intended to supplement and further refine previous investigation data to define of the nature and extent of PCE, support development of a three-dimensional (3D) groundwater model, and perform a baseline risk assessment. This Phase 2 Remedial Investigation Work Plan (RIWP) details the objectives, rationale, and methods for implementing the planned work for the Phase 2 RI. Project activities will be performed for the VA and USACE-KC. This document is organized in the following sections and appendices:

- **Section 1 – Introduction**. Provides the report purpose and organization.
- **Section 2 – Site Background**. Provides a discussion of the regulatory background of the Site, general site setting, and previous investigations conducted at the Site.
- **Section 3 – Preliminary Conceptual Site Model**. Provides a summary of preliminary conceptual site model (CSM) inputs for the Site.
- **Section 4 – Work Plan Rationale**. Provides a discussion of the rationale for the work plan, including data quality objectives (DQOs) and the work planning approach for Phase 2 of the RI.
- **Section 5 – Data Management, Reporting and Quality Assurance**. Describes how project data will be managed and reported, as well as project quality assurance (QA) procedures.

- **Section 6 – Schedule**. Provides the schedule for implementing the Phase 2 RI, including the field investigation and the RI report.
- **Section 7 – References**. Provides a list of references used to prepare this work plan.
- **Appendix A – Field Sampling Plan**. Provides the field sampling plan (FSP) and defines the field methods and procedures required to implement the Phase 2 field investigation and procedures for modifying planned work.
- **Appendix B – Quality Assurance Project Plan**. Presents the Phase 2 quality assurance project plan (QAPP) for collecting the type and quality of data needed to support environmental decision-making.
- **Appendix C – Investigation-Derived Waste Management Plan**. Presents the plan for managing investigation-derived waste (IDW) during the Phase 2 RI.
- **Appendix D – Accident Prevention Plan**. Provides the accident prevention plan (APP) health and safety requirements and procedures for safely conducting field work at the Site.
- **Appendix E – Data Management Plan**. The data management plan (DMP) presents the system of managing Site data and project documents.

Section 2

Site Location and Background

The Site is in Salt Lake City, near the University of Utah and the front of the Wasatch Mountains, at the intersection of 700 South and 1600 East (**Figure 2-1**). The Site is in a mixed commercial and residential area, and the major streets that bound it include 500 South to the north, Michigan Avenue to the south, 1100 East to the west, and Foothill Drive to the east. The Mount Olivet Cemetery, East High School, University of Utah athletics facilities, and residential neighborhoods are near the Site.

2.1 Regulatory History

PCE was initially detected at a concentration of 32 micrograms per liter (µg/L) during routine sampling of the Mount Olivet Cemetery irrigation well in 1990 (**Figure 2-2**) (Utah Department of Environmental Quality [UDEQ] 2000). Following this initial detection, the Site was investigated under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authority. UDEQ's Division of Environmental Response and Remediation, under agreement with the U.S. Environmental Protection Agency (EPA), conducted a site inspection (SI) from 1996 to 1999. Results from sampling in 1997 showed an increased concentration of PCE in the Mount Olivet Cemetery irrigation well (184 µg/L) and detectable levels of PCE in the Salt Lake City Department of Public Utilities drinking water well no. 18 (SLC-18).

In 1998 and 1999, six monitoring wells (five individual wells and one nested shallow/deep well) were installed at the Site by an EPA Superfund Technical Assessment and Response Team contractor. Results of the initial SI indicated the plume was greater than 900 feet wide at monitoring well EPA-MW-01 and limited to the shallow aquifer, with groundwater flow to the northwest (UDEQ 2000). The sewer line originating from the former dry cleaning facility at the VAMC was identified as a potential source area at this time (UDEQ 2000). A 2003 sanitary sewer survey documented multiple physical defects in the sewer line that may have contributed to the release of PCE (EPA 2012).

In 2004, an SI conducted by UDEQ and EPA detected PCE in SLC-18 at a concentration of 2.23 µg/L (UDEQ 2012). Although the measured value in SLC-18 was below the 5 µg/L National Drinking Water Standard maximum contaminant level (MCL) for PCE, the well was temporarily removed from service. During this event, PCE was also measured in the Mount Olivet Cemetery irrigation well at a concentration of 128 µg/L (UDEQ 2012). As a result of the SI, EPA returned to the Site in 2005 to prepare a Hazard Ranking System (HRS) package to propose the Site for inclusion on the National Priorities List (NPL). The decision to list the Site on the NPL was deferred to 2006 to allow local officials to seek congressional funding to address the contamination.

In June 2010, approximately 800 barrels of crude oil was released from a Chevron pipeline into Red Butte Creek and Liberty Park Pond. As a result of this release, the Salt Lake City Department of Public Utilities sampled 11 surface water springs along the Wasatch fault line to delineate the extent of crude oil contamination. PCE was detected in 6 of the 11 sampled springs, with concentrations ranging between 2.5 μg/L and 40.4 μg/L (EPA 2012). The area containing the surface water PCE detections was defined as the ESS area in subsequent investigations. The surface water detections were downgradient of the PCE plume at the Site and the plume was identified as a probable source of the surface water PCE contamination.

As a result of these detections, the Site was placed in the Comprehensive Environmental Response, Compensation, and Liabilities Information System in January 2011. A preliminary assessment (PA)/SI was conducted by UDEQ's Division of Environmental Response and Remediation in 2011. The PA/SI determined that PCE and its breakdown products present in spring water and shallow groundwater posed a potential human health threat (UDEQ 2011). In September 2012, EPA released the HRS site score and determined the Site was eligible for NPL designation. HRS documentation identified the sewer line originating from the VAMC as the source of the groundwater contamination and determined there was insufficient evidence to identify additional potential sources (EPA 2012). The Site was listed on the NPL on May 24, 2013, with the VAMC named as the potential responsible party (EPA 2014).

2.2 Geology, Hydrogeology, and Surface Water

Geologically, the Site is within the Salt Lake Valley, an alluvial basin bounded by the Wasatch Range, the Oquirrh Mountains, the Traverse Mountains, and the Great Salt Lake. The valley is within the Basin and Range physiographic province, which is characterized by north- to northeast-trending mountain ranges separated by broad alluvial basins. The Salt Lake Valley is bounded to the east by the Wasatch fault, an active fault zone composed of multiple seismically independent segments (EA 2017).

The Site is on Quaternary age unconsolidated sediments deposited by alluvial fans, streams, deltas, and lacustrine processes related to ancient Lake Bonneville. Overall, the surficial geology grades from coarse-grained alluvial fan deposits on the east, to finer-grained lacustrine deposits to the west. The topography of the Site slopes to the southwest at an approximate grade of 4 percent, until the grade steepens to 10 percent near the Wasatch fault scarp west of 1300 East, where springs and seeps emanate from the hillside (i.e., the ESS area). The Site is roughly bisected by the west and east spurs of the east branch of the Wasatch fault line (EA 2017). A detailed Site cross section is presented on **Figure 2-3**.

Groundwater flow in the Salt Lake Valley occurs in complex basin-fill deposits consisting of multiple aquifers and confining layers (EA 2017). Regional groundwater flow on the east side of the valley generally moves from the northeast to the southwest, from the primary recharge zone near the Wasatch Mountains toward the Jordan River, and then discharges to the Great Salt Lake (Thiros et al. 2010). Groundwater flow near the VAMC and the Site is more complex, with previous reports indicating local groundwater flow toward the northwest and the west-northwest (UDEQ 2000, EA 2017). There is considerable uncertainty in the understanding of local groundwater flow at the Site.

Surface water features near the 700 South and 1600 East PCE plume include Mount Olivet Reservoir, Red Butte Creek, Liberty Park Pond, named springs, and multiple unnamed seeps and springs.

2.3 Previous Remedial Investigations

Contaminants detected in groundwater at the Site include PCE and its degradation-related chlorinated volatile organic compounds (VOCs). The nature and extent of Site contaminants have not yet been fully characterized. Historically, the Site was divided into two OUs to investigate potential impacts to the environment and downgradient receptors. Accelerated Operable Unit 1 (AOU1) was designated based on the immediate public health concerns for residents of the ESS area related to indoor air inhalation exposure of PCE and its breakdown products. OU2 was designated for investigation and delineation of the groundwater PCE plume and source area. However, the VA has determined that AOU1 and OU2 will be combined into a single OU, the combined Operable Unit 1. Three key RI-related findings led to combining the OUs at the Site:

1. Identification of a PCE source at the VAMC near Buildings 6 and 7.
2. Installation of a monitoring well network, including transects, that indicates the presence of a PCE plume that appears to originate near the campus.
3. Investigation of AOU1 indicates vapor intrusion (VI) risk to the public is not pervasive (EA Engineering, Science, and Technology, Inc. [EA] 2019), and therefore it is no longer necessary to address VI risks under an accelerated OU.

These findings suggest a connection between the contamination present in the ESS neighborhood with the PCE plume downgradient of the VAMC. The former AOU1 and Phase 1 OU2 RI activities are summarized in the following sections.

2.3.1 AOU1 Remedial Investigation

The former AOU1 was implemented for the ESS area, where groundwater discharges by way of springs and seeps along the Wasatch fault. The ESS area includes the residential East Central, East Liberty Park, Yalecrest, and Gilmer Park neighborhoods. Red Butte Creek is south of AOU1 and flows west, toward Liberty Park Pond (**Figure 2-2**).

The investigation and remedial approach at AOU1 has focused on defining and mitigating VI arising from shallow groundwater contamination in this area. The AOU1 investigation was expedited to address potential public health risks while the long-term planning and investigation of the Site was ongoing. The goal of the AOU1 RI was to define the extent of potential impacts from VI, and if necessary, to mitigate VI on a structure-by-structure basis. Interim removal actions were to be implemented to address unacceptable risk identified at individual structures. The AOU1 RI field work commenced in late 2014 and was completed in spring 2017. The investigation included indoor air sampling of ESS structures, soil gas sampling in ESS, surface water sampling of ESS seeps and springs and Red Butte Creek, installation of monitoring wells within ESS, and groundwater sampling. The findings of the AOU1 RI are detailed in the AOU1 RI Report (EA 2019).

Based on the AOU1 RI, a time-critical removal action (TCRA) was implemented at one home within the ESS area. The TCRA is documented in an action memorandum dated October 20, 2016 (VA 2016).

2.3.2 OU2 Phase 1 Remedial Investigation

The focus of the RI at former OU2 is the evaluation of the nature and extent of the PCE plume, definition of the hydrostratigraphy and hydrogeology characteristics that control groundwater flow and contaminant migration, and investigation of the contamination source at the VAMC and along the sewer line beneath Sunnyside Park (**Figure 2-2**).

The Phase 1 RI field investigation was initiated in 2018 and is planned for completion in the summer of 2020. Field activities conducted in Phase 1 are summarized below. Monitoring well locations are shown on **Figure 2-2**.

- Soil gas surveys in three areas to identify potential sources of the PCE plume: outside VAMC Building 7, along the sewer line from Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VAMC.
- Installation of a transect near 1400 East consisting of a series of four shallow monitoring wells (MW-18, MW-19, MW-21, MW-22), one monitoring well cluster with shallower and deeper intervals (MW-20S/D), and two multilevel monitoring wells (MW-08 and MW-32) roughly perpendicular to the approximate groundwater flow path from the VAMC toward the ESS area. MW-33 is included in the scope for Phase 1 but has not been installed to date.
- Installation of a monitoring well transect along Guardsman Way, which consists of existing monitoring wells MW-02 and MW-04 and three new deep monitoring wells (MW-03R, MW-30, and MW-31).
- Installation of a monitoring well (MW-34) close to the location of the Mount Olivet irrigation well, which is near the southeastern corner of the cemetery.
- Installation of six monitoring well pairs (MW-12S/D, MW-13S/D, MW-14S/D, MW-15S/D, MW-16S/D, and MW-17S/D) in the ESS area.
- Installation of four monitoring wells (MW-23, MW-24, MW-27, and MW-28) near the source area near Building 6 and 7, and two monitoring wells (MW-25 and MW-26) downgradient of the source area near Buildings 6 and 7 on the VAMC campus. MW-23, MW-25, and MW-26 were installed as multilevel monitoring wells.
- Installation of a multilevel monitoring well (MW-29) in Sunnyside Park near a suspected former release point for PCE along the sanitary sewer line and near locations where elevated PCE concentrations were observed in soil vapor samples.
- Collection of multiple rounds of groundwater samples from new and existing monitoring wells.
- Collection of multiple rounds of surface water samples in the ESS area and along Red Butte Creek.

Additional details about the Phase 1 field investigation and rationale are included in the Phase 1 RIWP (CH2M 2018) and minor field modifications (MFMs) #1, #2, #3, #3a, and #4 (Jacobs 2019b, CDM Smith 2019a, CDM Smith 2019b, CDM Smith 2020a, CDM Smith 2020b, respectively).

Section 3

Preliminary Conceptual Site Model

The CSM for the Site is still being refined. Data collected in Phase 2 are intended to fill data gaps concerning the nature and extent of contaminated media and complete or potentially complete exposure pathways for human or ecological receptors. A preliminary CSM is presented in the Conceptual Site Model Update (EA 2017). Data collected in Phases 1 and 2 will be used to update the CSM for the Site.

3.1 Contaminants of Potential Concern

A preliminary list of contaminants of potential concern (COPCs) has been developed based on the investigations completed at the Site to date. They include PCE and its degradation products trichloroethene (TCE), cis-1,2-dichloroethene (1,2-DCE), and vinyl chloride (VC). The chemical 1,4-dioxane is also included as a preliminary COPC at the request of the EPA because of its historic use as a stabilizer primarily for 1,1,1-trichloroethane but also for PCE and TCE. Other contaminants identified during the RI will be evaluated to develop a comprehensive list of COPCs. The current understanding of the lateral extent of PCE contamination in groundwater at the Site is shown on **Figure 3-1**.

3.2 Data Gaps

At this time, while planning for Phase 2 of the RI, several activities are ongoing related to data collection under Phase 1. A comprehensive review of the Phase 1 data to identify remaining data gaps will be conducted after Phase 1 investigation activities have been completed and prior to implementation of Phase 2. However, the (verbatim) data gaps identified in the Phase 1 RIWP (CH2M 2018) are included below, along with a brief discussion of the current status (based on data collected in Phase 1 to date) and additional data needs for Phase 2.

- ***Source area identification*** *– Although the VAMC Building 7 has been identified as the likely source of the PCE plume, additional investigation is required to (1) definitively trace the PCE plume back to this location, (2) identify or eliminate other potential primary sources, and (3) determine if secondary sources downgradient of the primary source(s) may be contributing to PCE and TCE contamination at the Site. Soil gas survey data collected in the vicinity of the VAMC and the Sunnyside sewer line in Phase 1 of the RI will be used to determine to what extent a source can be identified. In addition, groundwater sampling results obtained in Phase 1 of the RI may be used to address this data gap and/or direct further sampling efforts.*

  - **Current Status**: Shallow soil vapor data collected from up to 15 feet below ground surface (bgs) under and around Buildings 6 and 7 during Phase 1 indicated the presence of PCE beneath both buildings, with the highest concentrations present in subslab soil vapor beneath Building 6 (up to 46,000 micrograms per cubic meter [$\mu g/m^3$]) (Jacobs 2019a). Soil vapor investigation along the Sunnyside Park sewer line indicated elevated concentrations of PCE in soil vapor near a manhole in the park (Manhole 22658), with a maximum concentration of 1,201 $\mu g/m^3$ (Jacobs 2019a).

These data, combined with historical knowledge of the Site, indicate that releases of PCE had likely occurred in these two primary areas, and that other potential primary sources are unlikely. These data also informed the proposed locations of soil borings and monitoring wells installed under MFM #3 (CDM Smith 2019b), which includes field screening of soil cores, collection of subsurface soil samples, collection of depth-discrete groundwater samples, and installation of groundwater monitoring wells to evaluate the extent of PCE contamination in this area.

- **Additional Data Needs**: In addition to the shallow soil vapor data collected in Phase 1, soil vapor probes were also installed inside the Phase 1 source area borings to evaluate the vertical extent of PCE impacts in the vadose zone in/near Buildings 6 and 7 and the Sunnyside Park manhole. These probes have not been sampled to date.

- ***Delineation of plume boundaries and PCE concentrations*** *– The dimensions of the Site PCE plume are not fully defined. Methods to address this data gap include monitoring well installation and groundwater sampling, soil gas analysis, direct-push soil sampling, and collection of surface water samples from springs and seeps along the Wasatch Fault.*

  - **Current Status**: Monitoring wells along the 1400 East transect were installed in 2018 to define the lateral extent of the plume, but the wells did not delineate the plume extents to the north along this transect. Vertical profiling sampling completed at MW-08 provided valuable information regarding the vertical extent of PCE impacts upgradient of the ESS. Installation of six well pairs (MW-12S/D, MW-13S/D, MW-14S/D, and MW-15S/D, MW-16S/D, and MW-17S/D) was completed in the ESS area to evaluate the extent of PCE impacts near the springs.

    Additional Data Needs: If the wells currently being installed during Phase 1 do not delineate the plume boundaries to the north and south along the Guardsman Way and 1400 East transects (specifically wells MW-30, MW-31, MW-32, and MW-33), then additional step-out wells would be necessary. While the well pairs installed in the ESS provide valuable information regarding PCE and TCE extent and appear to bound the plume to the southwest in the area west of the Wasatch fault, additional delineation is needed to confirm the lateral and vertical plume extent in the ESS area. In particular, the northern and northwestern portions of the plume are not well bounded. These data are key to understanding areas that may be affected by VI and where additional investigation may be necessary to evaluate risks due to VI. Collection of additional surface water samples is also necessary to aid in plume delineation in the northern and northwestern portion of the ESS area. In addition to evaluating the lateral and vertical extent of PCE at the Site, estimating mass discharge[1] in different areas of the plume is important for understanding source strength, fate and transport within the plume, evaluation of attenuation within the plume, and identification of areas where mass discharge is occurring to aid in future evaluation of remedial alternatives for the Site.

[1] [1] Mass flux is a rate measurement specific to a defined area, which is usually a subset of a plume cross section. Mass flux is expressed as mass/time/area (e.g., grams/day/square meter). Mass discharge is an integrated mass flux estimate (i.e., the sum of all mass flux measures across an entire plume) and represents the total mass of any solute conveyed by groundwater through a defined plane. Mass discharge is expressed as mass/time (e.g., grams/day).

- ***Characterization of the Site geology, hydrostratigraphy, and hydrogeology** – Understanding local groundwater flow is essential to characterizing this site. This data gap will be addressed by installing additional groundwater monitoring wells and the testing and sampling of new and existing wells. Site geology will be characterized through borehole logs, detailed lithology descriptions recorded during the installation of new monitoring wells, and geotechnical and geophysical measurements. The hydrogeology and hydrostratigraphy of the Site will be characterized through the installation of multi-level monitoring wells, geophysical measurements, aquifer testing on new and existing monitoring wells, the installation and monitoring of pressure transducers to monitor long-term fluctuations in water levels, and through collecting groundwater samples and field parameter data from new and existing wells. Data collected during Phase 1 will be used to develop a groundwater flow and transport plume model. The groundwater flow and transport plume model will be used to identify areas of low confidence where additional data may be required to reduce uncertainty.*

  - **Current Status**: Geologic data were collected from all wells installed to date during Phase 1 of the RI, and water level data collection is ongoing through synoptic water level measurement events completed during groundwater sampling and continuous measurement at select wells using transducers. Samples were also collected for geotechnical analysis at select locations.

  - **Additional Data Needs**: To date, aquifer tests (slug tests and pumping tests) have not been completed during Phase 1 to evaluate aquifer properties to support fate and transport evaluation and groundwater flow model development. These aquifer test data are important to understanding the hydraulic properties of the aquifer to develop the groundwater flow model. Additionally, geophysical tools, including nuclear magnetic resonance, natural gamma, and neutron gamma, will be used to supplement lithologic logs and provide data on permeability/porosity and soil type to develop a more robust groundwater flow model.

- ***Identification of potential exposure points** – Potential exposure points for the Site include exposure to groundwater through drinking water, contact with contaminated surface water in residential areas and storm drains, and contact with contaminated soil-gas through VI. Groundwater data will be essential to identifying the potential risk associated with exposure through irrigation and drinking water. Surface water, shallow groundwater, shallow soil, and soil gas data will provide additional information on the potential human health and ecological risks at the Site.*

  - **Current Status**: The identification of potential exposure points is ongoing during the RI process, and is driven by first delineating the extent of impacted soil, soil vapor, and groundwater in the plume and source areas.

- ***Evaluation of natural attenuation "lines of evidence" for PCE** – Hydrogeologic and geochemical data collected during Phase 1 of the RI will support evaluation of the extent to which natural attenuation may be occurring. Additional data will be collected in Phase 2 to support the evaluation.*

- **Current Status**: Geochemical data, including magnetic susceptibility of select soil samples and groundwater geochemical data (including total organic carbon, dissolved gases, anions, alkalinity, sulfide), have been collected to support evaluation of natural attenuation. Magnetic susceptibility of soils has also been measured during installation of wells during Phase 1 of the RI.

- **Additional Data Needs**: Additional information is needed to evaluate whether natural attenuation is occurring at the Site. Specifically, compound-specific isotope analysis (CSIA) of groundwater samples from select wells and the collection of geochemical data analysis of soil samples for total ferrous minerals content are needed. Data collection needs to support natural attenuation evaluation are included in Phase 2 of the RI.

The purpose of collecting data in Phase 2 is to close the identified data gaps for the Site. Further details on the Phase 2 principal study questions, proposed analytical approach, and the plan for obtaining data are provided in Sections 4 and 5.

Section 4

Work Plan Rationale

This section describes the DQOs for the Site and defines the RIWP approach and supporting documents.

4.1 Data Quality Objectives

Consistent with EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (2006), a seven-step process was followed to define DQOs for the Phase 2 RI. These DQOs serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the RI. The Phase 1 RIWP (CH2M 2018) defined the overarching DQOs to implement an RI at the Site. However, the DQOs for Phase 2 are intended to focus on data gaps remaining after implementing Phase I of the investigation. The seven-step DQO process includes the following:

- State the Problem
- Identify the Principal Study Questions
- Identify Information Inputs
- Define the Boundaries of the Study
- Develop the Analytic Approach
- Specify Performance or Acceptance Criteria
- Develop the Plan for Obtaining Data

The outputs of the DQOs process are presented in **Table 4-1**.

4.1.1 Planning Team Members

EPA is the lead regulatory agency for activities at the Site. The EPA Remedial Project Manager (RPM) is Mark Aguilar. UDEQ is a support agency for Superfund activities at the Site. The UDEQ RPM is Scott Lippitt.

The VA team includes Shannon Smith (RPM), Marc Yalom (Technical Manager), and Susanne Fairclough (Contracts Manager). The VA utilizes the U.S. Army Corps of Engineers (USACE) to manage the subcontractors for field, laboratory, and technical support, as necessary, for the project. The USACE Project Manager (PM) is Josephine Newton-Lund. USACE has contracted CDM Smith to perform RI activities under the supervision of EPA and UDEQ. The CDM Smith PM is Nathan Smith.

The project team organization chart is presented in Figure 2-1 of the QAPP (Appendix B). The key members of the DQO planning team for Phase 2 of the RI include the following:

- EPA: Mark Aguilar, David Berry (risk assessor)
- UDEQ: Scott Lippitt, Scott Everett (risk assessor)

- VA: Shannon Smith, Marc Yalom, Susanne Fairclough
- USACE: Josephine Newton-Lund, Greg Hattan, Dave Twigg
- CDM Smith: Nathan Smith, Neil Smith, Kent Sorenson, Lynn Woodbury, Karla Leslie, Kara Ali, Joseph Miller, David Sembrot

4.2 Work Planning Approach

Data collection during Phase 2 of the RI will be implemented to continue filling the data gaps identified while preparing the Phase 1 RI work plan, and to collect additional data necessary to answer the principal study questions identified in the updated DQOs presented in Section 4.1. This section describes the activities that will be completed during Phase 2 of the RI, as well as descriptions of several data collection tasks that are contingent upon completion of ongoing Phase 1 investigation activities.

4.2.1 Phase 2 Investigation Tasks

The key Phase 2 RI data collection activities to support the DQOs (**Table 4-1**) will include the following:

- Installation of additional monitoring wells to evaluate the lateral and vertical extent of COPCs. The well installation during Phase 2 will focus on completion of transects to evaluate mass discharge within the plume and to delineate the extent of the PCE plume to the north and northwest within the ESS area. Additionally, if the remaining Phase 1 RI wells do not adequately delineate the plume along the Guardsman Way and 1400 East transects, additional step-out wells will be installed in these areas. The potential for step-out borings is discussed further in Section 4.2.2 below. Data collection will support DQOs E1 (Hydrogeologic Features), E2 (Plume Characterization), and E3 (Plume Mass Discharge).

- Collection of geophysical data from select wells to evaluate aquifer properties to support development of the groundwater flow model and fate and transport evaluation. Data collection will support DQO E1 (Hydrogeologic Features).

- Completion of aquifer tests (pumping tests and/or slug tests) to measure hydraulic properties of the aquifer to support development of the groundwater flow model and fate and transport evaluation, and to support mass discharge evaluation. Data collection will support DQOs E1 (Hydrogeologic Features) and E3 (Plume Mass Discharge).

- Measuring water levels and calculating hydraulic gradients during synoptic water level measurement events and using transducers for continuous water level measurement at select locations. These data will support mass discharge estimation and fate and transport evaluation. Data collection will support DQOs E1 (Hydrogeologic Features), E2 (Plume Characterization), and E3 (Plume Mass Discharge).

- Groundwater sampling at existing and newly installed wells to evaluate VOC concentrations and aquifer geochemistry, evaluate VOC trends over time and plume stability, and support mass discharge estimation. Data collection will support DQOs E2 (Plume Characterization), E3 (Plume Mass Discharge), E4 (Natural Attenuation), D1 (Source Mass), and D3 (Groundwater Risk).

- Collection of groundwater samples from select wells for CSIA to evaluate attenuation of VOCs across the plume. Data collection will support DQO E4 (Natural Attenuation).
- Collection of subsurface soil data for total ferrous minerals analysis and magnetic susceptibility to support evaluation of abiotic attenuation mechanisms. Data collection will support DQO E4 (Natural Attenuation).
- Surface water sampling to aid in delineation of the PCE plume extent and to support risk assessment. Data collection will support DQOs E2 (Plume Characterization), D3 (Groundwater Risk), and D4 (Surface Water Risk).
- Collection of soil gas samples from vapor points installed during the Phase 1 investigation near Buildings 6/7 and Sunnyside Park to evaluate the lateral and vertical extent of PCE in the vadose zone, and from soil vapor points planned for installation during Phase 2 in the ESS area to evaluate areas where future VI sampling may be warranted. Data will also be used to evaluate whether PCE in the vadose zone is likely to act as a continuing source to groundwater. Data collection will support DQOs E2 (Plume Characterization), D1 (Source Mass), D2 (Source Area Vapor Intrusion Risk), and D3 (Groundwater Risk).
- Indoor air sampling and collection of other data to support VI evaluations will be conducted at approximately 20 homes at the Site, depending on the level of access granted by homeowners. Sampling will be conducted in accordance with the VI Protocol (CDM Smith 2019c), with additional provisions (e.g., no contact sampling) added to the protocol at a later date as necessary. In addition, replacement of select piezometers installed under AOU1 in the ESS area with shallow monitoring wells may be completed to provide additional data to inform future VI investigations. Data collection will support DQO D3 (Groundwater Risk).
- Surveying of sample locations and wells.

A summary of the ongoing Phase 1 RI tasks and anticipated Phase 2 tasks is presented in **Table 4-2**.

The data collected during Phase 1 and Phase 2 will be compiled into a 3D visualization platform to aid in data interpretation and refinement of the CSM. The 3D visualization will be used to evaluate the extent of PCE in the aquifer, evaluate geology/hydrostratigraphy, estimate mass discharge, and provide the basis for the model domain for the groundwater flow model.

The rationale for specific sample locations planned during Phase 2 is presented in the FSP (Appendix A).

4.2.2 Phase 1 RI Outcomes and Additional Investigation Tasks

Data collection activities planned for Phase 2 of the RI will be implemented to fill identified data gaps, to develop a more robust CSM, and to meet the DQOs. Currently, while planning for Phase 2 of the RI, several activities are ongoing related to data collection under Phase 1 of the RI, as detailed in the Phase 1 RIWP (CH2M 2018) and MFMs #1, #2, #3, #3a, and #4 (Jacobs 2019b, CDM Smith 2019a, CDM Smith 2019b, CDM Smith 2020a, CDM Smith 2020b, respectively). Therefore, portions of the proposed work for Phase 2 will require input or modification based on the results of the Phase 1 investigation work. This section identifies the proposed approach to data collection activities during Phase 2 of the RI where information from ongoing Phase 1 investigations are necessary to finalize locations for Phase 2 data collection. The summary below includes alternate data collection activities that may be completed based on outcomes of the ongoing Phase 1 data collection.

- Source area characterization during Phase 2 will focus on establishment of a transect of wells located in close proximity downgradient of the suspected or potential PCE release points at Building 6/7 and in Sunnyside Park. The majority of wells for this transect (MW-25, MW-26, and MW-29) are being installed as described in MFM #3 to the RIWP (CDM Smith 2019b). **Figure 4-1** presents the locations of the newly installed and proposed monitoring wells near the source areas.
    - If analytical results from Phase 1 groundwater sampling of newly installed wells indicate that the extent of PCE impacts has not been delineated to the northwest of Building 6/7, then an additional Phase 2 borehole/monitoring well (MW-35) will be added to extend the transect further north and to evaluate whether source mass may be present north of Building 7.
    - If horizontal hydraulic gradient evaluation using the newly installed wells indicates that the transect of wells is not located hydraulically downgradient of potential release points at Building 6/7, then additional Phase 2 borehole(s)/monitoring well(s) will be added to extend the transect further north or south.
- Delineation of the extent of PCE and degradation product impacts along the 1400 East transect during Phase 1 drilling may affect the desired well locations to delineate the extent of PCE impacts in the ESS area in Phase 2.
    - If the Phase 1 well analytical results indicate that the PCE plume extends further north than MW-33, at concentrations exceeding the lowest screening level, then the proposed well network for delineation in the ESS area will extend further north (MW-39S/D) in Phase 2 as indicated on **Figure 4-2**.
    - If the Phase 1 well analytical results indicate that the PCE plume does not extend further north than MW-33, at concentrations exceeding the lowest screening level, then the proposed well network for delineation in the ESS area in Phase 2 will be installed without the northernmost locations (MW-39S/D) as indicated on **Figure 4-2**.
- The Phase 1 drilling program includes installation of wells to delineate the lateral and vertical plume extents to the north and south at established transect locations (Guardsman Way and 1400 East transects).
    - If the Phase 1 wells do not delineate the extent of the plume to concentrations less than the lowest screening levels for PCE and its degradation products to the north and south, then step-out borings and monitoring wells will be advanced in Phase 2 to attempt to delineate the plume boundaries at the approximate locations indicated on **Figure 4-3** (purple step-out borings).

- If groundwater analytical results from the Phase 1 wells indicate that VOC concentrations are below screening levels, then the additional step-out borings indicated on **Figure 4-3** will not be necessary in Phase 2.

4.3 Supporting Documents

Supporting documents include the Phase 2 FSP (Appendix A), Phase 2 QAPP (Appendix B), IDW Management Plan (Appendix C), Accident Prevention Plan (Appendix D), and Data Management Plan (Appendix E).

4.3.1 Field Sampling Plan

The FSP defines the field methods and procedures required to implement the Phase 2 field investigation, as well as procedures for modifying planned work. The FSP is included as Appendix A.

4.3.2 Quality Assurance Project Plan

The QAPP addresses the collection and evaluation of data for the RI and presents the quality assurance (QA) objectives and quality control (QC) measures; procedures for sample collection and sample custody; details on analytical methods; and data reduction, validation, reporting, and assessment procedures. The QAPP is included as Appendix B.

4.3.3 Investigation-Derived Waste Management Plan

The IDW Management Plan (Appendix C) addresses the sampling, storage, and disposal of waste generated through RI field activities at the Site.

4.3.4 Accident Prevention Plan

The APP (Appendix D) documents the project organization, field tasks, and hazard controls for field activities.

4.3.5 Data Management Plan

The DMP (Appendix E) presents the system of managing Site data and project documents.

4.4 Groundwater Modeling

Data collected during Phase 1 and Phase 2 of the RI will be used to develop a comprehensive groundwater flow model and an associated solute transport model during the RI. Phase 2 work will complete any outstanding data gaps for the groundwater flow model. The development of the groundwater flow model/solute transport model will be guided by a technical memorandum that describes the proposed groundwater modeling approach. The groundwater modeling tasks proposed for the RI are intended primarily to improve our understanding of the fate and transport of the PCE plume under a range of potential future hydrologic and hydraulic conditions. At the end of the RI, it is also expected the groundwater model will be well-positioned to assist in the feasibility study for the project, which may include the simulation of potential remedial options. Below is a brief summary of the proposed groundwater modeling tasks to be undertaken during the RI.

- Submit the groundwater model QAPP describing the planned groundwater modeling approach
- Develop the CSM with a focus on model input data, data quality, and seamless integration with the 3D visualization model
- Select the numerical model codes to be used for groundwater flow, particle tracking, and solute transport
- Build the groundwater model
- Calibrate the groundwater model to transient conditions
- Conduct fate and transport simulations using the present-day PCE plume and future pumping/recharge conditions, which may include:
  - After identifying the most vulnerable water supply well, assume that well pumps at its maximum water right allocation for the next 20 years
  - Assume drier than average conditions over the next 20 years
  - Assume wetter than average conditions over the next 20 years
  - Assume the most vulnerable water supply well is taken out of service

Identification of the conditions to simulate will be made in collaboration with the project team to meet the objectives of the project. The numerical model development, calibration, and fate and transport simulations will be documented in a final modeling report, which will be included as an Appendix in the RI report.

4.5 Risk Assessment

A baseline risk assessment will be performed for the Site with results presented in the RI report. The risk assessment will include the following human health risk assessment (HHRA) elements:

- Site Background
  - Project Overview
  - Summary of AOU1 HHRA
- Data Evaluation
  - Data Selection (including what matrices, analytes, methods, locations, and dates will be included)
  - Data Adequacy and Quality Assessment
  - Sample Detection Limit Evaluation
  - Data Summary

- COPCs

- Exposure Assessment
  - Exposure Setting
  - Exposure Pathways
  - Exposure Point Concentrations
  - Quantification of Exposure Dose
- Toxicity Assessment
  - Noncancer Effects and Toxicity Values
  - Cancer Effects and Toxicity Values
- Risk Characterization
  - Basic Approach
  - Risk Interpretation
  - Risk Results and Weight-of-Evidence Evaluation
- Uncertainty Assessment
- Risk Summary

The scope of the ecological risk assessment will depend on the outcome of the ecological site reconnaissance and will begin with a screening-level ecological risk assessment (SLERA) of aquatic ecological receptors in creeks and ponds impacted by contaminated groundwater. Given the highly developed, urban setting of the study area and the nature of the Site contamination (volatile contaminants in groundwater), a baseline ecological risk assessment is likely not necessary.

The RI report will acknowledge the results of the AOU1 HHRA and SLERA (EA 2019) and the risk assessments will build upon the risk conclusions of the AOU1 assessments. Additional VI, ecological, and surface water risk evaluations will be included in the RI as appropriate to evaluate new data and assess exposure areas that were not part of the AOU1 evaluation (i.e., beyond the ESS area).

4.6 Modifications to Planned Work

Information gathered from Phase 1 and during implementation of tasks for Phase 2 could require a modification of subsequent tasks, including additional field work or other supporting field work. The VA will propose modifications per Federal Facilities Agreement Section 10.10, Subsequent Modification of Final Document. Changes to the RIWP that do not change a remedial action objective or DQO, or are necessitated by the condition or opportunities encountered in the field, will be addressed using MFMs. As an example, changes to proposed well locations or planned tasks may be required based on information gathered from previous tasks.

Section 5

Data Management, Reporting and Project Quality Assurance

This section describes how project data will be managed and reported, as well as project quality assurance (QA) procedures.

5.1 Data Management

A data management system has been set up to manage chemical, geological, hydrogeological, geospatial, and well-construction data, as well as project documents as described in the Data Management Plan included in Appendix E. Project field documentation will include field logbooks, field forms, photographs, and COC forms. The system is composed of the following major elements:

- An environmental data management system, housing the following data types:
  - Location information for wells and other sampling points
  - Well construction information
  - Simplified lithological information for boring logs
  - Water level data
  - Field parameters (for example, pH and specific conductivity)
  - Sample information including location, date and time, sampling method, and matrix
  - Analytical chemistry data
  - A geographic information system (GIS) using ArcGIS. The GIS will be used to house and visualize geospatial data, including project specific location information for wells, sample points, and reference entities such as roads, buildings, water bodies. The GIS will be integrated with EQuIS and will be accessible through a map widget.
- A document management system, consisting of a SharePoint website containing draft and final documents, native files, and scanned field documentation including field logbooks, field forms, photographs, and chain-of-custody forms

5.2 Reporting

An RI report for OU1 groundwater will be completed following implementation of the Phase 2 field investigation. Data summary reports for significant investigation activities (e.g., monitoring well installation or surface/groundwater sampling event) will also be prepared to document and communicate completed work tasks and significant findings.

5.2.1 Phase 2 Data Summary Reports

Data summary reports will summarize field activities, describe any variances and corrective action reports from the RIWP, and present raw data and field logs. The data summary reports will provide the necessary information to scope the next phase of field work and will collectively include:

- A summary of the field program activities, including any variances from the RIWP
- Boring, well construction, and well development logs from all new wells and a summary of well construction details
- Summary of data and interpretation of slug and aquifer tests
- Tabular results of geotechnical testing
- Geophysical and groundwater flow logs and a brief interpretation of results
- Graphical representation of groundwater analytical results and a potentiometric groundwater flow map
- Cross sections as appropriate to illustrate lithology, screen intervals, and PCE concentrations in clustered shallow and deep wells
- Surface water sampling logs and validated analytical results
- Groundwater sampling logs and validated analytical results
- Soil vapor sampling logs and validated analytical results
- Brief evaluation of hydrogeologic data gaps and recommendations for additional phases of the RI

5.2.2 Remedial Investigation Report

An RI report for OU1 groundwater will be prepared after completion of Phase 2 activities in accordance with EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1998). The RI report will include the following components:

- A summary of the field program activities, including any deviations from the RIWP
- Presentation and interpretation of analytical results
- A CSM illustrating contaminant release, fate and transport, exposure pathways and receptors
- Discussion of the nature and extent of contamination at the Site, including maps displaying sampling results and updated cross sections
- Discussion of the fate and transport of contaminants at the Site, including presentation of the development and results of the groundwater flow and solute transport models

- Baseline HHRA and baseline ecological risk assessment
- Investigation conclusions, including a discussion of the completeness of the RI for feasibility analysis of cleanup alternatives or interim actions, and objectives or recommendations for the next phase of work

The data summary reports described in Section 5.2.1 will also be included in the final RI report.

5.3 Project Quality Assurance

The contractor quality control plan (CQCP) (CDM Smith 2019d) describes the management structure and QA/QC procedures that CDM Smith will implement to ensure that RI activities are completed in accordance with project objectives and applicable requirements and standards. The CQCP was developed in accordance with USACE Engineering Regulation (ER) 1110-1-12, Engineering and Design - Quality Management (USACE 2006), and CDM Smith's QA Program. The QA staff identified in the project organization chart (see QAPP Figure 2-1 in Appendix B) will be responsible for QA oversight.

5.3.1 Field Audit

A field QA audit is an assessment of processes or activities conducted by an authorized independent auditor to verify conformance to specified requirements. A field audit will be conducted by an approved CDM Smith field auditor during the RI. The auditor will be independent from the project staff and will conduct an on-site evaluation shortly after the start of field activities to ensure all activities are being performed in accordance with the QAPP and specified SOPs. The field auditor is selected by the QA Manager (QAM) but is not necessarily a member of the QA staff. The auditor will prepare a report detailing the findings of the audit, which will be maintained in the project file. USACE will be notified at least 1 week prior to completion of the audit. A copy of the audit report will be provided to USACE following approval of the report by the CDM Smith QAM.

5.3.2 Laboratory Audit

A laboratory audit will be performed to check adherence to the applicable QA/QC requirements included in the subcontract analytical agreement and scope of work, and project QAPP, and to verify implementation of their quality system and SOPs relevant to the parameters of interest.

Section 6

Schedule

The proposed schedule for the Phase 2 RI field activities and associated deliverables is presented in **Table 6-1**. The CDM Smith PM will update the project schedule on a monthly basis, or more frequently if needed. The draft groundwater modeling technical memorandum is currently being developed. The memorandum will outline the groundwater modeling approach, including communications planning, model construction methodology, calibration approach, and describe the level of detail needed in the groundwater model to meet the RI project objectives. Once the groundwater modeling technical memorandum is approved by the regulators, a detailed groundwater flow model and solute transport model will be developed using data from the Phase 1 and 2 fieldwork, supplemented with historical data as appropriate. Visualization output will be generated to capture the results of these models and presented in the OU1 RI Report.

Table 6-1. Field Activity and Deliverable Schedule

Primary Document/Activity	Deliverable/ Activity Date	Review/Event Duration (Calendar Days)	Review Completion Date	Reviewer
Phase 2 Remedial Investigation Work Plan				
Draft RIWP	14-Aug-20	60	13-Oct-20	EPA/UDEQ
Draft Final RIWP	3-Nov-20	30	3-Dec-20	EPA/UDEQ
Final RIWP	17-Dec-20			
Phase 2 Field Investigation				
Quarterly GW Sampling Event	21-Sep-20	10		
Quarterly GW Sampling Event	8-Dec-20	10		
Phase 2 Drilling/Well Installation	30-Nov-20	40		
Remedial Investigation Report				
Draft RI	25-Jun-21	60	24-Aug-21	EPA/UDEQ
Draft Final RI	14-Sep-21	30	14-Oct-21	EPA/UDEQ
Final RI	28-Oct-21			

Section 7

References

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CDM Smith. 2020b. *Minor Field Modification #4 to OU-2 Remedial Investigation Work Plan. 700 South 1600 East Tetrachloroethene Plume Superfund Site*. Prepared for the U.S. Army Corps of Engineers, Kansas City District. June 3.

CDM Smith. 2019a. *Minor Field Modification #2 to OU-2 Remedial Investigation Work Plan. 700 South 1600 East Tetrachloroethene Plume Superfund Site*. Prepared for the U.S. Army Corps of Engineers, Kansas City District. October 17.

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CDM Smith. 2019c. *Final Vapor Intrusion Protocol. 700 South 1600 East Tetrachloroethene Plume Superfund Site*. Prepared for the U.S. Army Corps of Engineers, Kansas City District. December 13.

CDM Smith. 2019d. *Contractor Quality Control Plan. 700 South 1600 East Tetrachloroethene Plume Site, Salt Lake City, Utah.* Prepared for the U.S. Army Corps of Engineers, Kansas City District. November 22.

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UDEQ. 2011. *Preliminary Assessment – East Side Springs, Salt Lake County, Utah*. Division of Environmental Response and Remediation.

UDEQ. 2000. *Mount Olivet Cemetery Plume Analytical Results Report, UTD981548985*. Division of Environmental Response and Remediation. August.

Tables

1 - Problem Description: The U.S. Department of Veterans Affairs (VA) operated a part-time dry cleaning operation that used tetrachloroethene (PCE) over a 6-year period in the late 1970s and early 1980s. During this period, dry cleaning residuals were disposed of in the sanitary sewer. PCE-contaminated groundwater is present beneath the VA Medical Center (VAMC) property and the Sunnyside Park sewer line, as well as in areas hydraulically downgradient, extending to the East Side Springs (ESS) neighborhood (**Figure 2-1**). The site was placed on the EPA Superfund National Priority List in 2013 and is now referred to as the 700 South 1600 East PCE Plume Superfund Site (Site). The University of Utah, Mount Olivet Cemetery, and East High School, in addition to residential neighborhoods, are in the vicinity of the Site. The current conceptual site model is presented in the Conceptual Site Model Update (EA 2017), illustrating sources of contaminant release, fate and transport, potential exposure pathways, and receptors. Human exposure to PCE-contaminated groundwater is possible via existing or new water supply wells (including SLC-18 if it were brought back online). Additionally, humans may also be exposed due to vapor intrusion (VI) and direct-contact pathways associated with shallow groundwater and springs in the ESS area. Ecological receptors may encounter contaminated surface water and shallow groundwater. Although the Phase 1 Remedial Investigation (RI) and past investigations have collected measured concentrations of PCE and other volatile organic chemicals (VOCs) in various media, additional data are needed to characterize the hydrogeology and nature and extent of VOC contamination, to assess potential transport and exposure pathways and risks, and to inform the development and detailed analysis of remedial alternatives during the subsequent feasibility study (FS).

2 - Principal Study Question	3 - Information Inputs (1)	4 - Study Boundaries	5 - Analytical Approach	6 - Performance/Acceptance Criteria	7 - Plan for Obtaining Data
E1 (Hydrogeologic Features) What hydrogeologic features control VOC fate and transport? ***Estimation Statement:*** There are several hydrogeological features to be estimated that may control VOC fate and transport that vary across the site, including: location of faults, lithology, hydrostratigraphy, hillside discharge in the ESS area, hydraulic connection between the source area and production wells (i.e., SLC-18, University of Utah wells, and Mount Olivet well), hydraulic influence of Red Butte Creek, and groundwater flow direction and discharge. A 3-dimensional (3D) numerical groundwater model will be constructed and used in tandem with a 3D visualization model to incorporate these data into the Conceptual Site Model (CSM) and estimate their impact on the fate and transport of VOCs in groundwater.	The following information is needed to determine the hydrogeologic conditions, including: ▪ Lithology and hydrostratigraphy data (lithologic logs, piezometric head data, and extent and thickness of perching layers in the source area) ▪ Structural geology (fault trace and orientation) ▪ Borehole geophysical data (hydraulic conductivity and porosity provided by nuclear magnetic response, natural gamma/neutron gamma) ▪ Water levels and horizontal and vertical hydraulic gradients ▪ Recharge and pumping history ▪ Aquifer test results and estimated hydrogeological properties including transmissivity, hydraulic conductivity, and storativity ▪ Information on surface water discharges, seeps, and springs ▪ Influence of Red Butte Creek on groundwater flow direction and discharge The 3D numerical groundwater model should incorporate measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI).	The lateral study boundary is shown on **Figure 2-1** and is defined by areas where soil, groundwater, surface water, seep and spring water are known to have been impacted by PCE and degradation products from historic operations on the VAMC property. The known impacted area includes VOC-contaminated groundwater beneath the VAMC property and in areas hydraulically downgradient, extending to the ESS neighborhood. The vertical interval of VOC impacts will be evaluated at borings during this investigation. Because the lateral and vertical extent of the groundwater PCE plume has not been fully defined the spatial bounds of the study area could expand or be reduced as more information about the Site is obtained. Temporal boundaries will vary by information input. Geologic and hydrogeologic properties of the subsurface, including but not limited to lithology/hydrostratigraphy, structural geology, and geophysical properties are not expected to vary over time. Information inputs necessary to understand the hydrogeological controls on the plume, including water levels/hydraulic gradients, pumping history/rates at municipal and irrigation wells, vary over time. Water level and hydraulic gradient measurements will be completed over the course of at least one calendar year to account for seasonal variation. Historical and current well pumping data will be obtained to the extent practical, with monthly extraction data desired for at least one calendar year. There is limited space for installation of additional monitoring wells in the vicinity of Buildings 6 and 7 on the VAMC campus, thus	The study will estimate the transport characteristics (rate and direction) of VOC-impacted groundwater within the plume. The statistical parameter of interest when estimating hydrogeologic properties is the mean value of a hydrogeologic parameter measured at a specific well or borehole location. The information inputs will be integrated into a sitewide CSM, using 3D visualization tools and groundwater modeling software. If professional judgment shows too much uncertainty the hydrogeologic parameters of interest in specific locations or regarding specific factors, then additional data collection will be considered.	Site lithology and hydrostratigraphy varies across the Site and several hydrogeologic features have been identified that may control VOC fate and transport, including faults, hillside discharge in the ESS area, hydraulic connection between the source area and production wells (i.e., SLC-18, University of Utah wells, and Mount Olivet well), and the hydraulic influence of Red Butte Creek. Thus, measured hydrogeologic data should be spatially representative (i.e. laterally and vertically) of these hydrogeologic features. The hydrogeologic data inputs will be incorporated into the CSM using a 3D numerical groundwater model to estimate the impact of specific hydrogeological features on the fate and transport of VOCs in groundwater at the site. Data to support this study question will be collected in accordance with standard operating procedures presented in the QAPP to reduce the potential for sampling and measurement error and reduce uncertainty in the values.	Phase 2 investigation activities and proposed investigation locations are presented in Section 4.2 and Section 5 of this RI work plan. The specific hydrogeological data collection activities during Phase 2 include: ▪ Collect lithology, hydrostratigraphy, and borehole geophysical data from new and existing monitoring wells and assimilate information into a 3D visualization. ▪ Collect multiple rounds of water level data from new and existing wells, including synoptic water level measurement events at all wells, and transducer measurements at select wells. ▪ Perform aquifer tests on selected wells to characterize hydraulic properties in areas impacted by the PCE plume.

2 - Principal Study Question	3 - Information Inputs (1)	4 - Study Boundaries	5 - Analytical Approach	6 - Performance/Acceptance Criteria	7 - Plan for Obtaining Data
		collection of hydrogeologic data of desired density may be physically constrained by the structures in this area. Collection of borehole geophysical measurements is limited to wells which are constructed in a manner that is compatible with the logging tools used. The smallest estimation unit for estimating hydrogeologic parameters is a single hydrogeologic unit or feature (i.e. zones that have similar hydrogeologic characteristics and behavior). The 3D numerical groundwater model will be used as a tool to incorporate hydrogeologic data into the CSM to identify areas of low confidence where additional data may be required to refine the model output, thus spacing of boreholes/monitoring wells should be sufficient to keep model uncertainty within acceptable limits.			
E2 (Plume Characterization) What is the lateral and vertical extent of PCE and degradation products in groundwater downgradient from the source area? ***Estimation Statement:*** The extent of PCE and degradation products in groundwater at the Site is to be estimated during development of the CSM, using 3D visualization techniques to evaluate the lateral and vertical extent of groundwater containing VOCs. In combination with the evaluation of hydrogeological conditions, the transport of PCE and degradation products in groundwater will be evaluated to estimate flow paths and transport times. These data will be used to evaluate areas of the site where additional investigations may be necessary to evaluate risks to human receptors.	The following information is needed to determine the 3D extent of VOCs in the groundwater plume at the site: ▪ VOC concentrations in groundwater at monitoring wells, including temporal trends ▪ Well depth, screen interval, lithology, and ground surface and top of casing elevations ▪ Water levels and horizontal and vertical hydraulic gradients ▪ Maximum contaminant levels (MCLs) or applicable screening levels The analytical method should be selected such that the reporting limit (RL) for each VOC is below its respective MCL or applicable screening level for decision-making. The lateral and vertical extent of PCE and degradation products in groundwater should be derived using measured hydrogeologic and groundwater data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI).	The lateral study boundary is shown on **Figure 2-1**. The vertical interval of VOC impacts will be evaluated during this investigation. There is limited space for installation of additional monitoring wells in the vicinity of Buildings 6 and 7 on the VAMC campus (i.e. source area), thus installation of additional groundwater wells in this area may be physically constrained by the structures in this area. Additionally, the Site is located in a highly developed, urban/residential area where structures may restrict access to investigation in other areas. Ideally, monitoring well density should be sufficient to delineate the plume to within one city block. However, due to the size of the plume (approximately 300 acres) and the physical constraints on investigation in some areas, a 3-D groundwater transport model will be used to estimate groundwater concentrations between monitoring wells and in areas of low well density. Thus, spacing of boreholes/monitoring wells should be sufficient to keep model uncertainty within acceptable limits.	The statistical parameter of interest when estimating VOC concentrations in groundwater is the maximum detected concentration at a single well over a specified time period (e.g. one year). VOC concentration trends over a longer time period (i.e. multiple years) will also be evaluated to understand plume behavior and to monitor plume stability. A 3D visualization and a numerical groundwater model will be utilized to incorporate groundwater VOC concentration data into the CSM and to estimate the extent of PCE and degradation products in groundwater. If professional judgment shows too much uncertainty the interpretation of the lateral and vertical extent of PCE and degradation products in specific locations, additional data collection will be considered.	VOC concentrations in groundwater vary across the Site due to hydrogeologic conditions/features that influence groundwater flow paths and transport of contaminants from the source area to the downgradient groundwater plume. Thus, measured groundwater data should be spatially representative (i.e. laterally and vertically) of the varied hydrogeologic units at the Site. Data should also be spatially representative within the plume extent (i.e. source area, plume centerline, perimeter, toe of plume) to define the distribution of PCE and degradation products. An adequately spaced monitoring network is required to delineate the plume horizontally and vertically, and to monitor plume behavior and stability. Maximum concentrations of PCE and degradation products in groundwater at individual monitoring wells will be used in conjunction with a numerical groundwater flow and solute transport model to delineate the	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify data gaps in the estimation of the lateral and vertical extent of PCE and degradation products in groundwater. This evaluation will utilize a 3D groundwater transport model to incorporate Phase 1 groundwater VOC concentration data into the CSM. This information will be used to finalize or adjust proposed Phase 2 investigation locations, if necessary. Phase 2 investigation activities and proposed investigation locations are presented in Section 4.2 and Section 5 of this RI work plan. The specific data collection activities during Phase 2 include: ▪ Installation of new monitoring wells to define the northern and western extent of the plume. ▪ Installation of step-out wells where Phase 1 perimeter wells indicate VOC concentrations exceeding MCLs or screening levels.

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		VOC concentrations in groundwater vary over time due to migration of contaminants in the subsurface, and seasonal fluctuations in groundwater levels (e.g. due to infiltration from rainfall and irrigation and/or pumping from agricultural wells) that can alter groundwater flow paths and flow rates. Thus, measured VOC concentrations should be adequately representative of the full range of expected concentrations both within and between years. At a minimum, collection of data over the course of a calendar year is desired.		lateral and vertical extent of groundwater containing VOCs and to predict concentrations in areas of low well density. Professional judgment and model uncertainty will be used to determine if the interpolated distribution of PCE and degradation products in groundwater shows data gaps and too much uncertainty. Data to support this study question will be collected in accordance with standard operating procedures presented in the QAPP to reduce the potential for sampling and measurement error and reduce uncertainty in the values.	▪ Installation of monitoring wells in the ESS area to define the lateral and vertical extent of PCE and degradation products and the depth to impacted groundwater in areas susceptible to VI. ▪ Installation of additional borings and wells to delineate VOC impacts around Buildings 6/7 and Sunnyside Park. ▪ Collection of multiple rounds of groundwater VOC concentration data from all new and existing monitoring wells.
E3 (Plume Mass Discharge) What is the mass discharge [2] of PCE in groundwater at the source area and in the downgradient groundwater plume (i.e., mid plume and toe of plume)? ***Estimation Statement:*** The mass discharge of PCE that is occurring in the source area and in the downgradient groundwater plume is to be estimated during development of the CSM using PCE concentration and groundwater velocity data in conjunction with groundwater modeling techniques. Mass discharge estimates quantify source or plume strength at a given time and location and will be used to improve evaluation of natural attenuation and active remedial alternatives. These data will also improve assessment of risks posed by contamination to downgradient receptors, such as wells or surface water bodies.	The following information is needed to determine the mass discharge of PCE in the source area and downgradient groundwater plume: ▪ PCE concentrations in groundwater at monitoring wells in the source area and downgradient plume ▪ Well depth and screen interval ▪ Lithology and hydrostratigraphy data ▪ Groundwater (seepage) velocity estimates ▪ Water levels and horizontal and vertical hydraulic gradients ▪ Aquifer test results and estimated hydrogeological properties including transmissivity, hydraulic conductivity, and storativity The mass discharge of PCE in groundwater should be derived using measured hydrogeologic and groundwater data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI).	The lateral study boundary is shown on **Figure 2-1**. The vertical interval of VOC impacts will be evaluated during this investigation. VOC concentrations in groundwater vary across the Site due to hydrogeologic conditions/features that influence groundwater flow paths and transport of contaminants. Thus, data should be spatially representative within the plume extent (i.e. source area, mid plume, toe of plume) to define the discharge of PCE at different locations within the plume. There is limited space for installation of additional monitoring wells in the vicinity of Buildings 6 and 7 on the VAMC campus (i.e. source area), thus installation of additional groundwater wells in this area may be physically constrained by the structures in this area. Additionally, the Site is located in a highly-developed, urban/residential area where structures may restrict access to investigation in other areas. The smallest estimation unit for estimating the discharge of PCE in groundwater is a monitoring well transect comprised of at least 3 monitoring wells.	The statistical parameter of interest when estimating concentrations of PCE in groundwater is the maximum detected concentration at a single well over a specified time period. When estimating groundwater velocity, the statistical parameter of interest is the mean at a single monitoring well or monitoring location over a specified time period. Vertical transects will be created at some well locations by installing wells screened in multiple hydrogeologic units. The mass discharge of PCE will be estimated at the source area, mid plume, and the toe of the plume using measured and estimated groundwater velocity and PCE concentration data in conjunction with a numerical groundwater model and professional judgement.	Adequately located monitoring well transects (i.e. source area, mid plume, and toe of plume), oriented perpendicular to the direction of groundwater flow, are required to estimate the discharge of PCE in groundwater at the source area and in the downgradient groundwater plume. The transect method will be used to estimate mass discharge, in which individual monitoring points are used to integrate concentration and flow data. Mass discharge will be estimated at various locations in the plume by analyzing new and existing flow rate and VOC concentration data along transects oriented perpendicular to isocontours (or along transects using existing monitoring wells), as well as by using a solute transport model requiring flow and concentration data as input parameters. Data to support this study question will be collected in accordance with standard operating procedures presented in the QAPP to reduce the potential for sampling and	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify data gaps in the estimation of the lateral and vertical extent of PCE in groundwater. This evaluation will utilize a 3D groundwater transport model to incorporate Phase 1 groundwater VOC concentration data into the CSM. If the 3D model or professional judgment indicates too much uncertainty in specific locations, additional data collection will be considered in Phase 2. Collection of additional data may include: ▪ Installation of one or more new monitoring wells in the source area (i.e. VAMC and Sunnyside Park) to complete a well transect for evaluation of PCE mass discharge. ▪ Completion of a monitoring well transect upgradient of the ESS area to evaluate PCE mass discharge at the toe of the plume. ▪ Collection of groundwater VOC concentration data from new and existing monitoring wells.

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				measurement error and reduce uncertainty in the values.	▪ Collection of lithology, hydrostratigraphy, and borehole geophysical data from new monitoring wells. ▪ Measurement of hydraulic conductivity at transect well locations ▪ Collection of water level data from new and existing wells and calculation of hydraulic gradients
E4 (Natural Attenuation) How does natural attenuation change the concentrations of PCE and degradation products in the source area vadose zone and downgradient groundwater plume? ***Estimation Statement:*** The extent of natural attenuation that is occurring in the source area vadose zone and/or downgradient groundwater plume is to be estimated using both direct and indirect measurements. Direct measurements provide an estimation of the reduction in PCE and degradation products, while indirect measurements provide an estimation of the potential of attenuation to occur and how complete the attenuation process may be. Degradation mechanisms will also be compared with VOC data to evaluate if decreasing concentrations of total VOCs or individual VOC constituents are observed alongside evidence of biotic/abiotic attenuation mechanisms.	The following information is needed to determine whether natural attenuation is occurring in the source area vadose zone and/or downgradient groundwater plume: ▪ Vadose and saturated zone mineral properties (specifically ferrous iron minerals, magnetic susceptibility, and fraction of organic carbon) ▪ Stable isotope composition of source mass and dissolved PCE (and degradation products) ▪ Reduction/oxidation geochemical data and dissolved oxygen ▪ Biological data supporting the assessment of reductive dechlorination ▪ Groundwater (seepage) velocity estimates incorporating aquifer hydraulic properties, horizontal and vertical gradients ▪ Temporal and spatial concentrations of VOCs in groundwater and estimates of plume mass to determine if the plume is stable, expanding, or retracting The analytical method for VOCs should be selected such that the RL for each VOC is below its respective MCL or applicable screening level for decision-making. The evaluation of natural attenuation potential of PCE in groundwater should be derived using measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI).	The lateral study boundary is shown on **Figure 2-1**. The vertical interval of VOC impacts will be evaluated during this investigation. Aquifer conditions and VOC concentrations in groundwater vary across the Site due to various factors that influence geochemical parameters and transport of contaminants from the source area to the downgradient groundwater plume. Thus, measured geochemical data should be spatially representative (i.e. laterally and vertically) within the plume boundary. Aquifer conditions also vary over time due to seasonal fluctuations in groundwater levels (e.g. due to rainfall and irrigation) that can alter geochemical conditions in groundwater. Thus, measured geochemical data should be adequately representative of the full range of expected aquifer conditions both within and between years. For performance of CSIA, monitoring wells should be selected with concentrations at or above 5 parts per billion (ppb) for proper analysis of isotope composition and evaluation of the extent of biotic and abiotic degradation occurring in the plume. The smallest decision unit for making decisions regarding the occurrence of natural attenuation should be a distinct plume area or hydrogeologic unit (e.g., source area vadose zone). Because attributes that influence natural attenuation processes can vary	The statistical parameter of interest when estimating concentrations of PCE and degradation products in groundwater or soil is the maximum detected concentration at a single well or sampling location. In assessing natural attenuation occurrence and potential, biodegradation is the most important destructive attenuation mechanism, although abiotic destruction of some compounds can occur. Other, nondestructive attenuation mechanisms can also occur, including sorption, dispersion, dilution from recharge, and volatilization. Site data will be evaluated using the following lines of evidence as outlined in the OSWER Directive 9200.4-17 (1997). (1) Historical ground water and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. In the case of a ground water plume, decreasing concentrations should not be solely the result of plume migration. (2) Hydrogeologic and geochemical data that can be used to indirectly demonstrate the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels. For	Representative groundwater VOC concentration data, as well as other data noted in Step 3, are required to estimate the extent of natural attenuation of PCE that is occurring in the source area vadose zone and the downgradient groundwater plume. This evaluation will be conducted using multiple lines of evidence to determine the extent to which natural attenuation changes the concentrations of PCE and degradation products in the source area vadose zone and downgradient groundwater plume, and the controlling mechanisms (both destructive and nondestructive). For example, even if PCE concentrations are not decreasing in groundwater, combined CSIA evaluation and microbial analysis can be used to indicate that biotic or abiotic degradation is occurring at the Site, and that other mechanisms (e.g., diffusion from soil) could be causing groundwater PCE concentrations to remain stable.	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify data gaps for determining if natural attenuation is occurring at the Site and what mechanisms control attenuation. The specific data collection activities during Phase 2 include: ▪ Collection of geochemical data from all monitoring wells to provide a temporal and spatial distribution of geochemical conditions to evaluate the potential of abiotic or biotic degradation ▪ Collection of groundwater samples at existing and newly-installed wells to evaluate VOC concentrations and aquifer geochemistry, and to evaluate VOC trends over time, ▪ Collection of groundwater samples from select wells for compound-specific isotope analysis to evaluate attenuation of VOCs across the plume. ▪ Collection of subsurface soil data for total ferrous minerals analysis, and magnetic susceptibility to support evaluation of abiotic attenuation mechanisms.

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		spatially, data from each unit or area must either be measured or predicted with reasonable certainty.	example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the rates of biological degradation processes occurring at the site. (3) Data from field or bench scale studies that directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (e.g. biological degradation processes).		
D1 (Source Mass) Is there sufficient mass of PCE in the vadose zone in the source area to act as an ongoing source of PCE in groundwater? ***Alternative study outcomes:*** ▪ If yes: Evaluation of response actions would need to consider alternatives that include source treatments to address contaminant mass in the vadose zone. ▪ If no: The evaluation of response actions may not need to include a detailed analysis of alternatives that include source treatment. ***Decision Statement:*** Evaluate whether there is sufficient source mass of PCE in the vadose zone to act as an ongoing source of PCE in groundwater. Delineation of PCE in the vadose zone and determination of PCE mass discharge at the source area will be used in the evaluation. If soil-to-groundwater migration is found to be occurring, evaluation of response actions would need to consider alternatives that include source treatments to address contaminant mass in the vadose zone.	The following information is needed to determine the PCE mass in the source area contributing to an increase in dissolved concentrations: ▪ Source area temporal and spatial groundwater VOC concentration data ▪ Source area spatial soil VOC data ▪ Source area spatial and temporal soil gas VOC data ▪ Vadose zone and saturated zone lithological and hydraulic data The analytical method for VOC analysis should be selected such that the RL for each VOC is below its respective MCL or applicable screening level for decision-making. The source mass evaluation should be derived using measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI).	Currently the source area is not well defined, therefore the lateral extent of the study area is the vicinity of the VAMC Buildings 6 and 7 and the Sunnyside Park sewer line (**Figure 2-2**). The vertical extent of subsurface investigation is limited to the vadose and saturated groundwater zones beneath the source area to a depth of approximately 400 feet. There is limited space for installation of additional monitoring wells in the vicinity of Buildings 6 and 7 on the VAMC campus, thus installation of additional groundwater wells in this area may be physically constrained. VOC concentrations in groundwater vary over time due to migration of contaminants in the subsurface, and seasonal fluctuations in groundwater levels (e.g. due to infiltration from rainfall and irrigation and/or pumping from agricultural wells) that can alter groundwater velocities and flow paths. VOC concentrations in soil gas also vary over time, thus, measured VOC concentrations should be adequately representative of the full range of expected concentrations both within and between years. The smallest decision unit for making source response decisions is the individual source area (i.e. Building 6 and 7 on the VAMC campus and the Sunnyside sewer line). Because these two distinct source areas likely have a different mass of PCE acting as a source	The statistical parameter of interest when estimating concentrations of PCE and degradation products in groundwater or soil gas is the maximum detected concentration at a single well or sampling point over a specified time period. Determination of the presence or absence of sufficient PCE mass in the vadose zone will be conducted using measured and estimated hydrogeologic and VOC concentration data in conjunction with a numerical groundwater model and professional judgement.	Representative source area groundwater, soil, and soil gas VOC concentration data, as well as lithologic and hydraulic data are required to determine if there is sufficient mass of PCE in the vadose zone in the source area to act as an ongoing source of PCE in groundwater. This evaluation will be conducted using multiple lines of evidence to determine if source mass is present and if it acts as an ongoing source for groundwater. For example, lines of evidence indicating the absence of sufficient source mass in the vadose zone may include: ▪ Maximum concentrations of VOCs in source area soil that are less than the soil screening level protective of groundwater ▪ Soil gas VOC concentration data that demonstrate a meaningful decreasing concentration trend over time at source area sampling points ▪ Recent groundwater VOC concentration data indicating concentrations are less than the MCL over multiple quarters or sampling events ▪ Groundwater VOC concentration data that demonstrate a meaningful decreasing concentration trend	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify data gaps for determining if there is sufficient mass of PCE in the source area to act as an ongoing source of PCE in groundwater. Collection of additional data to support this evaluation in Phase 2 may include: ▪ Sampling existing source area soil gas probes. ▪ Collecting vadose zone soil samples from new borings/monitoring wells near source areas.

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		to groundwater, data from each area must either be measured or predicted with reasonable certainty.		over time at source area monitoring wells ▪ Mass discharge estimates and/or groundwater modeling results indicating low plume strength in the source area Alternatively, the absence of some or all of these lines of evidence may indicate that there is sufficient contaminant mass in the vadose zone to act as an ongoing source to groundwater, and evaluation of response actions may need to consider alternatives that include source treatments to address contaminant mass in the vadose zone.	
D2 (Source Area Vapor Intrusion Risk) Would human exposure to site-related VOCs in the source area vadose zone via VI result in unacceptable risks? ***Alternative study outcomes:*** ▪ If yes: Evaluation of response actions would need to consider alternatives that include source treatments to address contaminant mass in the vadose zone. ▪ If no: The evaluation of response actions may not need to include a detailed analysis of alternatives that include source treatment. ***Decision Statement:*** Evaluate whether human exposure to site-related VOCs in the source area vadose zone near VAMC Buildings 6 and 7 by way of VI would result in unacceptable risks. If unacceptable risks are identified, evaluation of response actions would need to consider alternatives that include source treatments to mitigate VI risks.	The following information is needed to quantify human exposures and risks from source area VOCs in soil gas: ▪ Measured concentrations of VOCs in soil gas near and beneath VAMC Buildings 6 and 7 ▪ Measured concentrations of VOCs in indoor air at VAMC Buildings 6 and 7 ▪ Exposure parameters for human receptor populations ▪ Toxicity thresholds for evaluating non-cancer and cancer risks for human populations The analytical method should be selected such that the RL for each VOC is below its respective concentration-based toxicity threshold for decision-making. Exposure point concentrations (EPCs) for VOCs in soil gas and indoor air should be derived using measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI). Exposure parameters for the human receptor populations of interests should be based on USEPA default exposure assumptions, derived from national exposure data (e.g., USEPA Exposure Factors Handbook), site-specific data, or using best professional judgement.	Potential human receptors for this site include indoor workers and other special populations (i.e., child care center and a residential scenario with the veterans home and Valor House on the VAMC campus) that may come in contact with source area contamination via VI and inhalation of indoor air at Buildings 6 and 7. The lateral study boundary is the area in and around VAMC Buildings 6 and 7. When quantifying air exposures inside buildings, because there can be indoor sources of VOCs (not related to source area soil/soil gas contamination), such as dry cleaned clothing, brake cleaners, and glues, characterizing background levels of VOCs from these non-site-related indoor sources is useful for interpreting site risks. The smallest decision unit for making risk management decisions should be a single building. Because each building can have building-specific attributes that influence indoor air concentrations, data from each potentially-impacted building must either be measured or predicted with reasonable certainty.	The statistical parameter of interest when estimating human exposures is the mean across the entire exposure area of interest and entire exposure timeframe of interest. The exposure area and timeframe depend upon the receptor of interest. For example, for residential indoor exposures, the exposure area is the house and the default exposure duration is 26 years (6 years as a child and 20 years as an adult). However, the EPC should represent the spatially- and time-weighted average. The USEPA RSL and VISLs will be used to compute non-cancer hazard quotients (HQs) and cumulative hazard indices (HIs) and cumulative cancer risk estimates. As appropriate, site-specific assumptions will be used to derive screening levels for the receptor-specific exposure scenario of interest. If estimated cancer risks are greater than 1E-04 and/or estimated HI is greater than 1, then risks will be deemed unacceptable and an evaluation of response actions would need to consider alternatives that include source treatments to mitigate VI risks. If estimated cancer risks are less than or equal to 1E-06 and/or estimated	The following are the null (H_0) and alternative (H_A) hypotheses for the evaluation of source area VI risks: H_0: Human exposures to site-related VOCs in the source area vadose zone via VI are greater than the level of concern. H_A: Human exposures to site-related VOCs in the source area vadose zone via VI are less than or equal to the level of concern. In making decisions about human health risks, two types of decision errors are possible: • A Type I (false negative) decision error would occur if a risk manager decides that VOC exposure is not of health concern, when, in fact, it is of concern (i.e., false rejection of the H_0 hypothesis). • A Type II (false positive) decision error would occur if a risk manager decides that VOC exposure is above a level of concern, when, in fact, it is not	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify additional data required to quantify risks from human exposure to site-related VOCs in source area soil gas via VI. Collection of additional data to support this evaluation in Phase 2 may include: ▪ Sampling existing source area soil gas probes. ▪ Collecting additional indoor air samples at VAMC Buildings 6 and 7.

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	The toxicity thresholds used for risk management decision-making should be derived from two main sources of risk-based thresholds – the USEPA Regional Screening Levels (RSLs) and the USEPA Vapor Intrusion Screening Levels (VISLs).	VOC concentrations in indoor air can vary due to many factors, such as, but not limited to, source concentrations, building floor level, and air flow. For the purposes of risk estimation, it is most important to characterize air concentrations in rooms inside the building where the receptors have the highest exposure frequency. VOC concentrations in soil gas and indoor air have the potential to vary over time. For example, VOC concentrations in indoor air attributable to VI are likely to be highest in the winter and lowest in the summer. The human health risk assessment will quantify average long-term chronic exposures under both current and future site conditions. Thus, measured VOC concentrations should be adequately representative of the full range of expected concentrations both within and between years. If it is not possible to collect data to represent the full range of concentrations, to ensure decisions are risk-protective, data should be representative of time periods and locations that are likely to be from the high-end of the exposure distribution.	HI is less than or equal to 1, then risks will be deemed acceptable and a detailed analysis of remedial alternatives for the mitigation of source area contaminant mass would not be necessary. If estimated cancer risks are between 1E-06 and 1E-04, which is within the USEPA acceptable risk range, then risk managers may need to consider site-specific attributes to make appropriate risk management decisions.	(i.e., false acceptance of the H_0 hypothesis). Risk managers are most concerned about guarding against the occurrence of false negative decision errors, since an error of this type may leave humans exposed to unacceptable levels of VOCs. In general, the goal is to limit the probability of a false negative decision error to no more than about 5% (i.e., $\alpha = 0.05$). This is accomplished by using the 95% upper confidence limit of the arithmetic mean (95UCL) as the EPC, rather than the sample mean, in risk calculations. Use of the 95UCL to estimate risk helps account for limitations in the data, ensuring that risk estimates are more likely to overestimate than underestimate the true risk level. A minimum of 3 samples is needed to compute the 95UCL; however, the target number of samples to compute a reliable EPC is 8 to10 samples. The actual number of samples collected will be determined as part of the study design, taking into consideration the exposure scenario, exposure area size, anticipated spatial and temporal variability in concentrations, and project budget. If the number of samples collected is too small to calculate the 95UCL, the maximum concentration may be used in the risk evaluation as an estimate of the EPC. Risk managers are also concerned with the probability of making false positive decision errors. Although this type of decision error does not result in unacceptable human exposure, it may result in unnecessary expenditure of resources (i.e., in investigating and remediating source area soil that does not result in	

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				unacceptable risks). The probability of a false positive decision error is greatest when the EPC is close to the decision threshold. In general, the goal is to limit the probability of a false positive decision error to no more than 20% (i.e., $\beta = 0.20$) when the true risk is within a factor of 2 of the level of concern. The required sample size to limit the false positive error rate will depend upon the underlying variability in the VOC concentrations for the medium of interest (i.e., the chemical-specific standard deviation). When the standard deviation is small, fewer samples are needed to limit the false positive error rate; when the standard deviation is large, a high number of samples are needed to limit the false positive error rate.	
D3 (Groundwater Risk) Would human exposures to site-related VOCs in groundwater within the plume area result in unacceptable risks? ***Alternative study outcomes:*** ▪ If yes: Evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in groundwater for the pathways where unacceptable risks were identified. ▪ If no: Evaluation of response actions would not include a detailed analysis of remedial alternatives for the mitigation of groundwater. ***Decision Statement:*** Evaluate whether human exposures to site-related VOCs in groundwater would result in unacceptable risks. If unacceptable risks are identified an evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in groundwater for the pathways where unacceptable risks were identified.	The following information is needed to quantify human exposures and risks from VOCs in groundwater: ▪ Measured concentrations of VOCs in groundwater from aquifers that could be used as drinking or irrigation water under current or future conditions ▪ Measured concentrations of VOCs in groundwater that could be a source of VI exposures ▪ Measured concentrations of VOCs in soil gas that could be a source of VI exposures ▪ Measured concentrations of VOCs in indoor air inside buildings that could be impacted by VI ▪ Measured concentrations of VOCs in shallow groundwater in the ESS area that could be a source of exposure for construction workers ▪ Exposure parameters for human receptor populations and pathways of potential concern for groundwater exposure scenarios ▪ Toxicity thresholds for evaluating non-cancer and cancer risks for human populations The analytical method should be selected such that the RL for each VOC is below its respective	Potential human receptors for this site include residents, building occupants, and construction workers that may contact contaminated groundwater via a drinking water supply well or through VI and direct contact pathways associated with shallow groundwater. The lateral study boundary is shown on **Figure 2-1**. Within the study area, the exposure areas of interest are determined by the groundwater plume extent. The exposure areas of interest include the ESS neighborhood, as well as other locations and buildings outside this neighborhood within the current footprint of the known groundwater plume (see **Figure 3-2**). However, because the lateral extent of the groundwater plume has not been fully defined, the spatial bounds of the exposure areas could expand or be reduced as more information about the Site is obtained.	The statistical parameter of interest when estimating human exposures is the mean across the entire exposure area of interest and entire exposure timeframe of interest. The exposure area and timeframe depend upon the receptor of interest as discussed above. The EPC should represent the spatially- and time-weighted average. The USEPA RSL and VISLs will be used to compute non-cancer hazard quotients (HQs) and cumulative hazard indices (HIs) and cumulative cancer risk estimates. As appropriate, site-specific assumptions will be used to derive screening levels for the receptor-specific exposure scenarios of interest. If estimated cancer risks are greater than 1E-04 and/or estimated HI is greater than 1, then risks will be deemed unacceptable and an evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in groundwater for the pathways where unacceptable risks were identified. If estimated cancer	The following are the null (H_0) and alternative (H_A) hypotheses for the evaluation of groundwater risks: H_0: Human exposures to site-related VOCs in groundwater within the plume area are greater than the level of concern. H_A: Human exposures to site-related VOCs in groundwater within the plume area are less than or equal to the level of concern. As described above, to avoid the potential for a false negative decision error, the 95UCL on the mean should be used as the basis of the EPC for both human health and terrestrial ecological receptors. Use of the 95UCL limits the probability of a false negative decision error to no more than about 5%. The minimum of samples to compute the 95UCL is 3 samples; however, 8 to10 samples would be needed to compute a	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify additional data required to quantify human exposures and risks from VOCs in groundwater. Collection of additional data to support this evaluation in Phase 2 may include: ▪ Sampling existing soil gas probes. ▪ Collecting indoor air samples inside buildings that could be impacted by VI ▪ Collecting multiple rounds of groundwater VOC concentration data from new and existing monitoring wells

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	concentration-based toxicity threshold for decision-making. EPCs for VOCs in various media should be derived using measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI). Exposure parameters for the human receptor populations of interests should be based on USEPA default exposure assumptions, derived from national exposure data (e.g., USEPA Exposure Factors Handbook), site-specific data, or using best professional judgement. The toxicity thresholds used for risk management decision-making should be derived from two main sources of risk-based thresholds – the USEPA Regional Screening Levels (RSLs) and the USEPA Vapor Intrusion Screening Levels (VISLs).	The smallest decision unit for making risk management decisions should be a single building (e.g., one residential home). Because each building can have building-specific attributes that influence indoor air concentrations, data from each potentially-impacted building must either be measured or predicted with reasonable certainty. Risks from VI will be quantified for properties within the groundwater plume boundary where there is the potential for VI to occur.	risks are less than or equal to 1E-06 and/or estimated HI is less than or equal to 1, then risks will be deemed acceptable and a detailed analysis of remedial alternatives for the mitigation of groundwater would not be necessary. If estimated cancer risks are between 1E-06 and 1E-04, which is within the USEPA acceptable risk range, then risk managers may need to consider site-specific attributes to make appropriate risk management decisions for groundwater.	reliable EPC. The goal is to limit the probability of a false positive decision error to no more than 20% when the true risk is within a factor of 2 of the level of concern.	
D4 (Surface Water Risk) [(3)] Would human and ecological exposures to site-related VOCs in surface water (i.e., springs, creeks, ponds, irrigation water) within the groundwater plume area result in unacceptable risks? ***Alternative study outcomes:*** ▪ If yes: Evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in surface water for the pathways and receptors where unacceptable risks were identified. ▪ If no: Evaluation of remedial alternatives would not include a detailed analysis of remedial alternatives for the mitigation of surface water. ***Decision Statement:*** Evaluate whether human and/or ecological exposures to site-related VOCs in surface water would result in unacceptable risks. If unacceptable risks are identified an evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in surface water for the pathways and receptors where unacceptable risks were identified.	The following information is needed to quantify human and ecological exposures and risks from VOCs in surface water: ▪ Measured concentrations of VOCs in surface water (i.e., springs, creeks, ponds, irrigation water) that could be impacted by contaminated VOCs associated with the site ▪ Exposure parameters for human receptor populations and pathways of potential concern for surface water exposure scenarios ▪ Toxicity thresholds for evaluating non-cancer and cancer risks for human populations ▪ Toxicity thresholds for evaluating exposures by aquatic receptors, plants, birds, and mammals The analytical method should be selected such that the RL for each VOC is below its respective concentration-based toxicity threshold for decision-making. EPCs for VOCs in surface water should be derived using measured data collected during all phases of the RI (i.e. AOU1 RI, Phase 1 OU2 RI, and Phase 2 OU1 RI). Exposure parameters for the human receptor populations of interests should be based on USEPA default exposure assumptions, derived from	Potential human receptors for this site include residents and outdoor workers that may contact contaminated surface water (i.e., springs, creeks, ponds, irrigation water). Potential ecological receptors may include aquatic receptors (e.g., aquatic plants, invertebrates, fish), terrestrial plants, birds, and mammals (both wildlife and domesticated pets) that may contact contaminated surface water. The lateral geographic boundary of the study area is shown on **Figure 2-1**. Within the study area, the exposure areas of interest are determined by the groundwater plume extent and the locations where impacted surface water is present. This includes both areas where contaminated shallow groundwater is surfacing, such as seeps and springs, as well as creeks and ponds that are infiltrated by contaminated shallow groundwater. The exposure areas of interest include the springs, creeks, and ponds within the ESS neighborhood, as well as other surface water locations outside this neighborhood within the current footprint of the known groundwater plume (**Figure 3-2**). The exposure areas of	**Human Health:** The statistical parameter of interest when estimating human exposures is the mean across the entire exposure area of interest and entire exposure timeframe of interest. The exposure area and timeframe depend upon the receptor of interest. The EPCs will be used to compute non-cancer HQs and HIs and cumulative cancer risk estimates. As appropriate, site-specific assumptions will be used to derive risk estimates for the receptor-specific exposure scenarios of interest. If estimated cancer risks are greater than 1E-04 and/or estimated HI is greater than 1, then risks will be deemed unacceptable and an evaluation of response actions would need to consider alternatives that mitigate exposure to VOCs in surface water for the pathways where unacceptable risks were identified. If estimated cancer risks are less than or equal to 1E-06 and/or estimated HI is less than or equal to 1, then risks will be deemed acceptable and a detailed analysis of remedial alternatives for the mitigation	The following are the null (H_0) and alternative (H_A) hypotheses for the evaluation of surface water risks: H_0: Human and/or ecological exposures to site-related VOCs in surface water within the plume area are greater than the level of concern. H_A: Human and ecological exposures to site-related VOCs in surface water within the plume area are less than or equal to the level of concern. As described above, to avoid the potential for a false negative decision error, the 95UCL on the mean should be used as the basis of the EPC for both human health and terrestrial ecological receptors. Use of the 95UCL limits the probability of a false negative decision error to no more than about 5%. The minimum of samples to compute the 95UCL is 3 samples; however, 8 to10 samples would be needed to compute a reliable EPC. The goal is to limit the probability of a false positive decision	Prior to initiation of the Phase 2 investigation, an evaluation of data from Phase 1 will be completed to identify additional data required to quantify human exposures and risks from VOCs in surface water. Collection of additional data to support this evaluation in Phase 2 may include: ▪ Collecting surface water VOC concentration data from springs, creeks or ponds that could be impacted by contaminated VOCs associated with the site

2 - Principal Study Question	3 - Information Inputs (1)	4 - Study Boundaries	5 - Analytical Approach	6 - Performance/Acceptance Criteria	7 - Plan for Obtaining Data
	national exposure data (e.g., USEPA Exposure Factors Handbook), site-specific data, or using best professional judgement. The human health toxicity thresholds used for risk management decision-making should be derived from the USEPA RSLs and the USEPA National Ambient Water Quality Criteria (NAWQC) for human health. The ecological toxicity thresholds should be based on USEPA NAWQC for aquatic life (i.e., both the criterion maximum concentration [CMC] and the criterion continuous concentration [CCC]) and other commonly used toxicity benchmark sources in the available scientific literature (e.g., Los Alamos National Laboratory ECORISK Database screening levels for surface water).	interest also include locations where impacted groundwater is being used for surface irrigation. As noted above, because the lateral extent of the groundwater plume has not been fully defined, the lateral bounds of the exposure areas could expand or be reduced as more information about the Site is obtained. The smallest decision unit for making risk management decisions should be a single property (e.g., for residential exposure scenarios), a single well (e.g., for irrigation water), or a unique surface water feature (e.g., a specific spring, creek, or pond). If there are spatial gradients in concentration within a surface water feature, it may be appropriate to split the feature into smaller exposure areas. VOC concentrations in surface water have the potential to vary over time. Additionally, there are also differences in the exposure potential as a function of time. Terrestrial receptors, such as humans, birds, and mammals, are likely to have more frequent exposure to surface water in the spring and summer, and less exposure during the fall and winter when surface water features are absent or frozen. The human health risk assessment will quantify average long-term chronic exposures under both current and future site conditions. Thus, measured VOC concentrations should be adequately representative of the full range of expected concentrations both within and between years. If it is not possible to collect data to represent the full range of concentrations, to ensure decisions are risk-protective, data should be representative of time periods and locations that are likely to be from the high-end of the exposure distribution.	of surface water for human health would not be necessary. If estimated cancer risks are between 1E-06 and 1E-04, which is within the USEPA acceptable risk range, then risk managers may need to consider site-specific attributes to make appropriate risk management decisions for surface water. **Aquatic Ecological Receptors:** The statistical parameter of interest when estimating aquatic ecological receptor exposures is the mean across the entire exposure area of interest; however, the exposure timeframe of interest depends upon the basis of the toxicity threshold. A four-day averaging period should be used when evaluating chronic exposures, while a one-hour averaging period should be used when evaluating acute exposures. Ideally, continuous surface water monitoring data would be collected that allows for the computation of both the four-day and one-hour averages. If continuous monitoring data cannot be collected, each sample should be evaluated as representing both the four-day average and the one-hour average and risks interpreted based on the frequency and magnitude of CMC and CCC exceedances. **Terrestrial Ecological Receptors:** The statistical parameter of interest when estimating terrestrial ecological exposures is the mean across the entire exposure area of interest and entire exposure timeframe of interest. Similar to human health, for terrestrial ecological receptors, the goal is to quantify long-term chronic exposures (e.g., year-long). For ecological receptors (aquatic and terrestrial), if estimated HQs are greater than 1, then ecological risks will be deemed unacceptable and an evaluation of response actions may need to consider alternatives that mitigate exposure to VOCs in surface water for the pathways	error to no more than 20% when the true risk is within a factor of 2 of the level of concern.	

2 - Principal Study Question	3 - Information Inputs [1]	4 - Study Boundaries	5 - Analytical Approach	6 - Performance/Acceptance Criteria	7 - Plan for Obtaining Data
			where unacceptable risks were identified. If estimated HQs are less than or equal to 1, then risks will be deemed acceptable and a detailed analysis of remedial alternatives for the mitigation of surface water would not be necessary for ecological receptors.		

[1] Step 3 of the DQO process identifies all of the data inputs required to answer the principle study questions. In some cases, adequate data for inputs identified in this step may be available from previous investigations (i.e. AOU1 RI and OU2 Phase 1 RI) and may not require collection of additional data in Phase 2.

[2] Mass flux is a rate measurement specific to a defined area, which is usually a subset of a plume cross section. Mass flux is expressed as mass/time/area (e.g., grams/day/square meter). Mass discharge is an integrated mass flux estimate (i.e., the sum of all mass flux measures across an entire plume) and represents the total mass of any solute conveyed by groundwater through a defined plane. Mass discharge is expressed as mass/time (e.g., grams/day).

[3] Evaluation of surface water risk will only be considered for areas not evaluated in the AOU1 HHRA and SLERA (EA 2019).

Remedial Investigation Task Description (1)		
Phase 1 (2)		
Source Area Soil Gas Survey – Soil gas surveys in three areas to identify potential sources of the PCE plume:: outside George E. Wahlen Veterans Affairs Medical Center (VAMC) Building 7, along the sewer line from Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VAMC. Soil probes also installed in source area soil borings (MW-23, MW-24, MW-25, MW-27, MW-28, MW-29, MW-30, MW-32), but not sampled in Phase 1.		
1400 East Monitoring Well Transect - Installation of a transect near 1400 East consisting of a series of four shallow monitoring wells (MW-18, MW-19, MW-21, MW-22), one monitoring well cluster with shallower and deeper intervals (MW-20S/D), and two multilevel monitoring wells (MW-08 and MW-32) roughly perpendicular to the approximate groundwater flow path from the VAMC toward the East Side Springs (ESS) area. MW-33 is included in the scope for Phase 1 but has not been installed to date.		
Guardsman Way Monitoring Well Transect - Consists of existing monitoring wells MW-02 and MW-04 and installation of three new deep monitoring wells (MW-03R, MW-30, and MW-31).		
Mt. Olivet Cemetery Monitoring Well – Installation of monitoring well (MW-34) close to the location of the Mount Olivet irrigation well.		
ESS Monitoring Wells - Installation of six monitoring well pairs, MW-12S/D, MW-13S/D, MW-14S/D, MW-15S/D, MW-16S/D, and MW-17S/D.		
Source Area Monitoring Wells - Installation of four monitoring wells (MW-23, MW-24, MW-27, and MW-28) near the source area near VAMC Buildings 6 and 7, and two monitoring wells (MW-25 and MW-26) downgradient of the source area. MW-23, MW-25, and MW-26 were installed as multilevel monitoring wells.		
Sunnyside Park Monitoring Well - Installation of a multilevel monitoring well (MW-29) in Sunnyside Park near a suspected former release point for PCE along the sanitary sewer line and near locations where elevated PCE concentrations were observed in soil vapor samples.		
Groundwater Sampling - Collection of multiple rounds of groundwater samples from new and existing monitoring wells.		
Surface Water Sampling - Collection of multiple rounds of surface water samples in the ESS area and along Red Butte Creek.		
Phase 2	**Dependent on Phase 1 Data?**	**Dependent on Phase 2 Data?**
Source Area Monitoring Well Installation - Source area characterization during Phase 2 will focus on establishment of a transect of wells located in close proximity downgradient of the suspected or potential tetrachloroethene (PCE) release points at VAMC Buildings 6/7 and in Sunnyside Park. The majority of wells for this transect (MW-25, MW-26, and MW-29) are being installed in Phase 1.	Yes. If analytical results from Phase 1 groundwater sampling of newly installed wells indicate that the extent of PCE impacts has not been delineated to the northwest of Building 6/7, then an additional Phase 2 borehole/monitoring well will be added to extend the transect further north, and an additional Phase 2 borehole will be advanced to evaluate whether source mass may be present north of Building 7 as indicated on **Figure 4-1**.	Yes. If horizontal hydraulic gradient evaluation using the newly installed wells indicates that the transect of wells is not located hydraulically downgradient of potential release points at Building 6/7, then additional Phase 2 borehole(s)/monitoring well(s) will be added to extend the transect further north or south.
ESS Area Monitoring Well Installation - Installation of additional monitoring wells to delineate the extent of the PCE plume to the north and northwest within the ESS area and completion of the 1400 East transect to evaluate mass discharge within the plume.	Yes. Delineation of the extent of PCE and degradation product impacts along the 1400 East transect during Phase 1 drilling may affect the desired well locations to delineate the extent of PCE impacts in the ESS area in Phase 2. ▪ If the Phase 1 well analytical results indicate that the PCE plume extends further north than MW-33, at concentrations exceeding the lowest screening level, then the proposed well network for delineation in the ESS area will extend further north in Phase 2 as indicated on **Figure 4-2**. ▪ If the Phase 1 well analytical results indicate that the PCE plume does not extend further north than MW-33, at concentrations exceeding the lowest screening level, then the proposed well network for delineation in the ESS area in Phase 2 will be installed without the northernmost locations (MW-39S/D) as indicated on **Figure 4-2**.	No.
Guardsman Way and 1400 East Transects - Installation of additional monitoring wells to evaluate the lateral and vertical extent of COPCs. Additional step-out wells will be installed in these areas if the remaining Phase 1 RI wells do not adequately delineate the plume along the Guardsman Way and 1400 East transects.	Yes. The Phase 1 drilling program includes installation of wells to delineate the lateral and vertical plume extents to the north and south at established transect locations (Guardsman Way and 1400 East transects). ▪ If the Phase 1 wells do not delineate the extent of the plume down to below the lowest screening levels for PCE and its degradation products to the north and south, then step-out borings and monitoring wells will be advanced in Phase 2 to attempt to delineate the plume boundaries at the approximate locations indicated on **Figure 4-3**. ▪ If groundwater analytical results from the Phase 1 wells indicate that VOC concentrations are below screening levels, then the additional step-out borings indicated on **Figure 4-3** will not be necessary in Phase 2.	No.

Remedial Investigation Task Description [1]		
Phase 2 (continued)	**Dependent on Phase 1 Data?**	**Dependent on Phase 2 Data?**
Geophysical Data - Collection of geophysical data from select wells to evaluate aquifer properties to support development of the groundwater flow model and fate and transport evaluation.	Yes. Final well construction for the Phase 1 wells will be evaluated to determine if they are suitably constructed to support geophysical evaluation.	No.
Aquifer Testing - Completion of aquifer tests (pumping tests and/or slug tests) to measure hydraulic properties of the aquifer to support development of the groundwater flow model and fate and transport evaluation, and to support mass discharge evaluation.	No.	Yes. Slug tests at selected monitoring wells will be completed first. The slug test results will be evaluated and may be used to finalize proposed pumping well locations and observation well locations for pumping tests.
Water Levels - Measuring water levels and hydraulic gradients during synoptic water level measurement events and using transducers for continuous water level measurement at select locations. These data will support mass discharge estimation and fate and transport evaluation.	No.	No.
Groundwater Sampling - sampling at existing and newly installed wells to evaluate VOC concentrations and aquifer geochemistry, evaluate VOC trends over time, and support mass discharge estimation. Groundwater samples will also be collected from select wells for compound specific isotope analysis (CSIA) to evaluate attenuation of volatile organic constituents (VOCs) across the plume.	Yes. Wells selected for the initial phase of CSIA evaluation will be finalized after receipt of analytical data from the newly-installed Phase 1 monitoring wells.	Yes. Collection of data to support additional natural attenuation lines of evidence (i.e. additional CSIA data, microbial analyses) may be conducted depending on the outcome of the initial CSIA evaluation and the results of groundwater samples collected during Phase 2.
Subsurface Soil - Collection of subsurface soil data for total ferrous minerals analysis and magnetic susceptibility to support evaluation of abiotic attenuation mechanisms.	No.	No.
Soil Gas - Collection of soil gas samples from vapor points installed during the Phase 1 investigation near Buildings 6/7 and Sunnyside Park to evaluate the lateral and vertical extent of PCE in the vadose zone, and from soil vapor points planned for installation during Phase 2 in the ESS area to evaluate areas where future vapor intrusion sampling may be warranted.	No.	Yes. Soil vapor points in the ESS area may be adjusted, or additional points added, based on the groundwater analytical results from new monitoring wells installed to delineate the extent of PCE impacts in the ESS area during Phase 2.
Surface Water - Surface water sampling to aid in delineation of the PCE plume extent and to support risk assessment.	No.	Yes. Surface water sample locations may be adjusted from the current planned locations based on the groundwater analytical results from new monitoring wells installed to delineate the extent of PCE impacts in the ESS area during Phase 2.
Vapor Intrusion – Indoor air sampling and collection of other data to support vapor intrusion (VI) evaluations will be conducted at approximately 20 homes at the Site to evaluate VI risk at structures within the plume boundary. In addition, replacement of select piezometers installed under AOU1 in the ESS area with shallow monitoring wells may be completed to provide additional data to inform future VI investigations.	Yes. Shallow groundwater VOC concentration data and soil gas data collected in Phase 1 and Phase 2 will be used to delineate the plume extent and identify structures within the plume boundary where additional VI assessment is warranted.	Yes. Shallow groundwater VOC concentration data and soil gas data collected in Phase 1 and Phase 2 will be used to delineate the plume extent and identify structures within the plume boundary where additional VI assessment is warranted.
Surveying - Surveying of sample locations and wells.	No.	No.

(1) Monitoring well locations are shown on Figure 2-2.
(2) Remedial investigation tasks listed have or will be completed during Phase 1.

Figures

Legend

George E. Wahlen Veterans Affairs Medical Center Boundary

Study Area Boundary

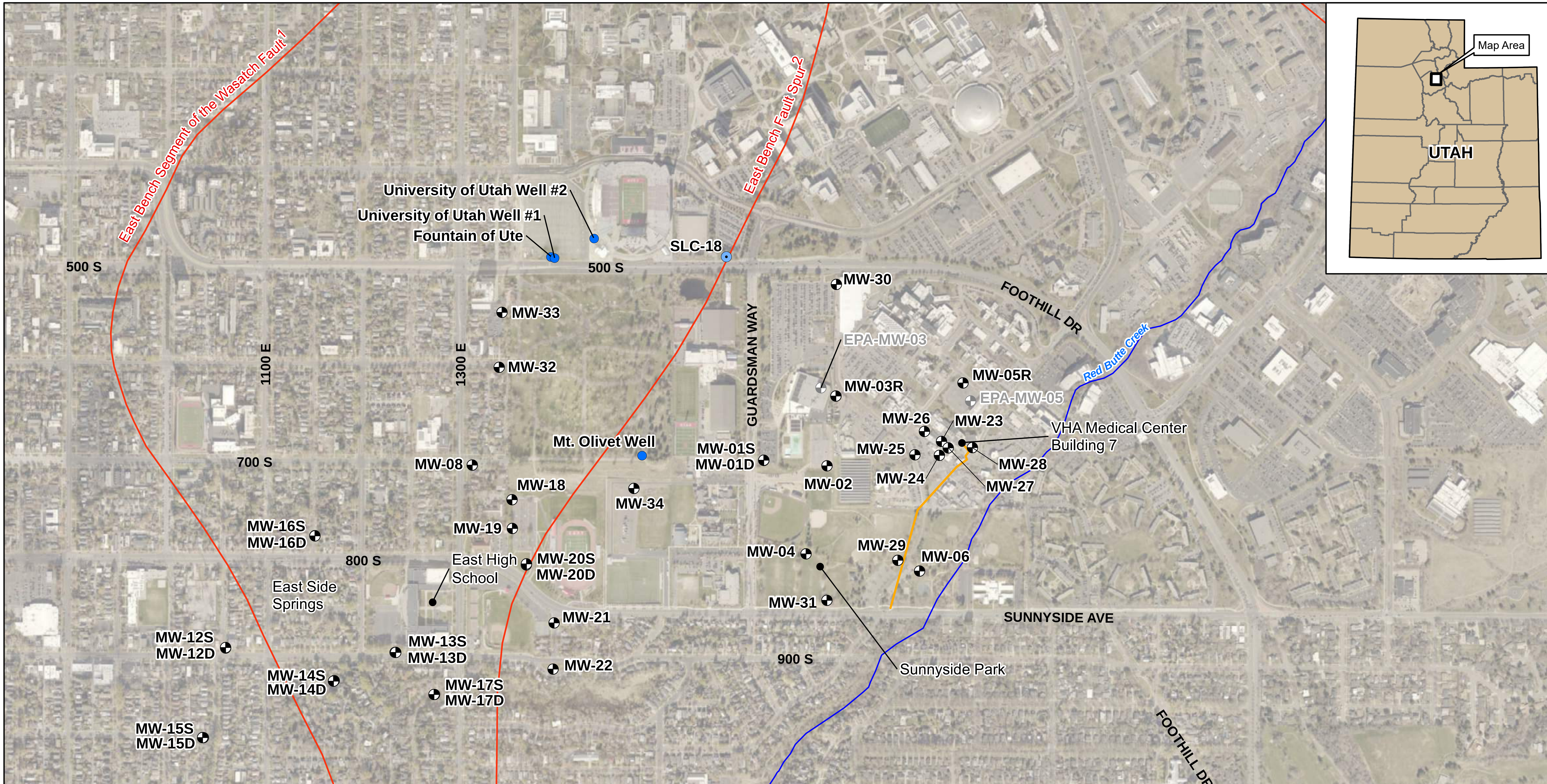
FIGURE 2-1
SITE LOCATION MAP

N

0 500 1,000 Feet

CDM Smith

Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend

- Monitoring Well
- Decommissioned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Sewer Line
- Fault Line

Notes:
(1) Location of University of Utah Well #1 is approximate; well is located less than 100 feet east of Fountain of Ute.

OU = operable unit
PCE = tetrachloroethene
VHA = Veterans Health Administration

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

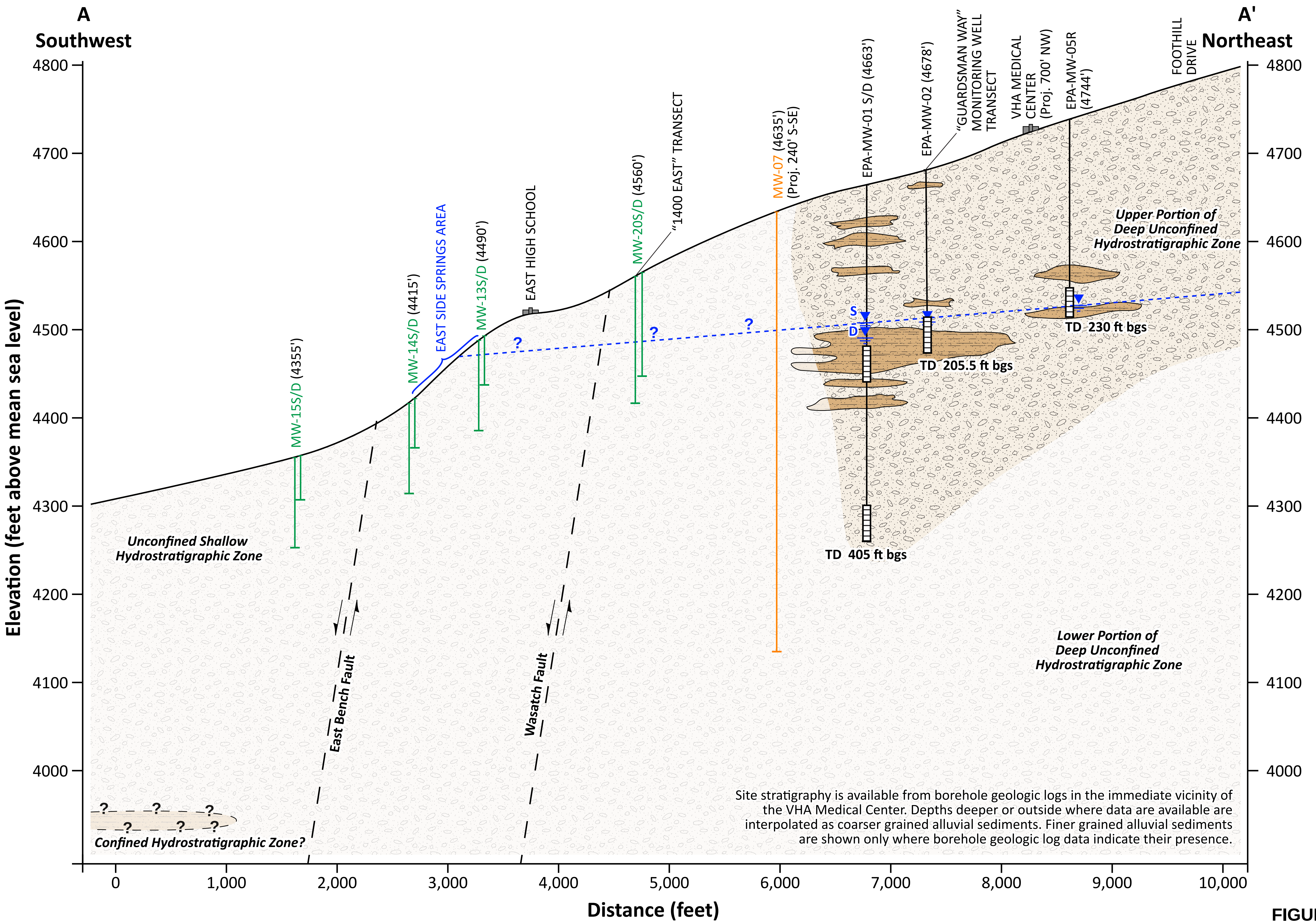
0 500 1,000 Feet

CDM Smith

FIGURE 2-2
SITE MAP

Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2020\RIWP_2020\Fig2-2_RIWP_SiteMap.mxd PORTERFIELDJE 7/29/2020



Legend

- Proposed shallow monitoring well location (See Note 3)
- Proposed deep monitoring well location (See Note 5)
- EPA monitoring well
- Water Level
- Finer grained alluvial sediments classified as clay (CL), gravelly clay (GC), or sandy clay (SC)
- Coarser grained alluvial sediments
- S: shallow
- D: deep
- TD = total depth
- ft bgs = feet below ground surface
- ? = Uncertainty
- (4355') = Elevation in feet above mean sea level

100'
8X VERTICAL EXAGGERATION
800'
North

NOTES:

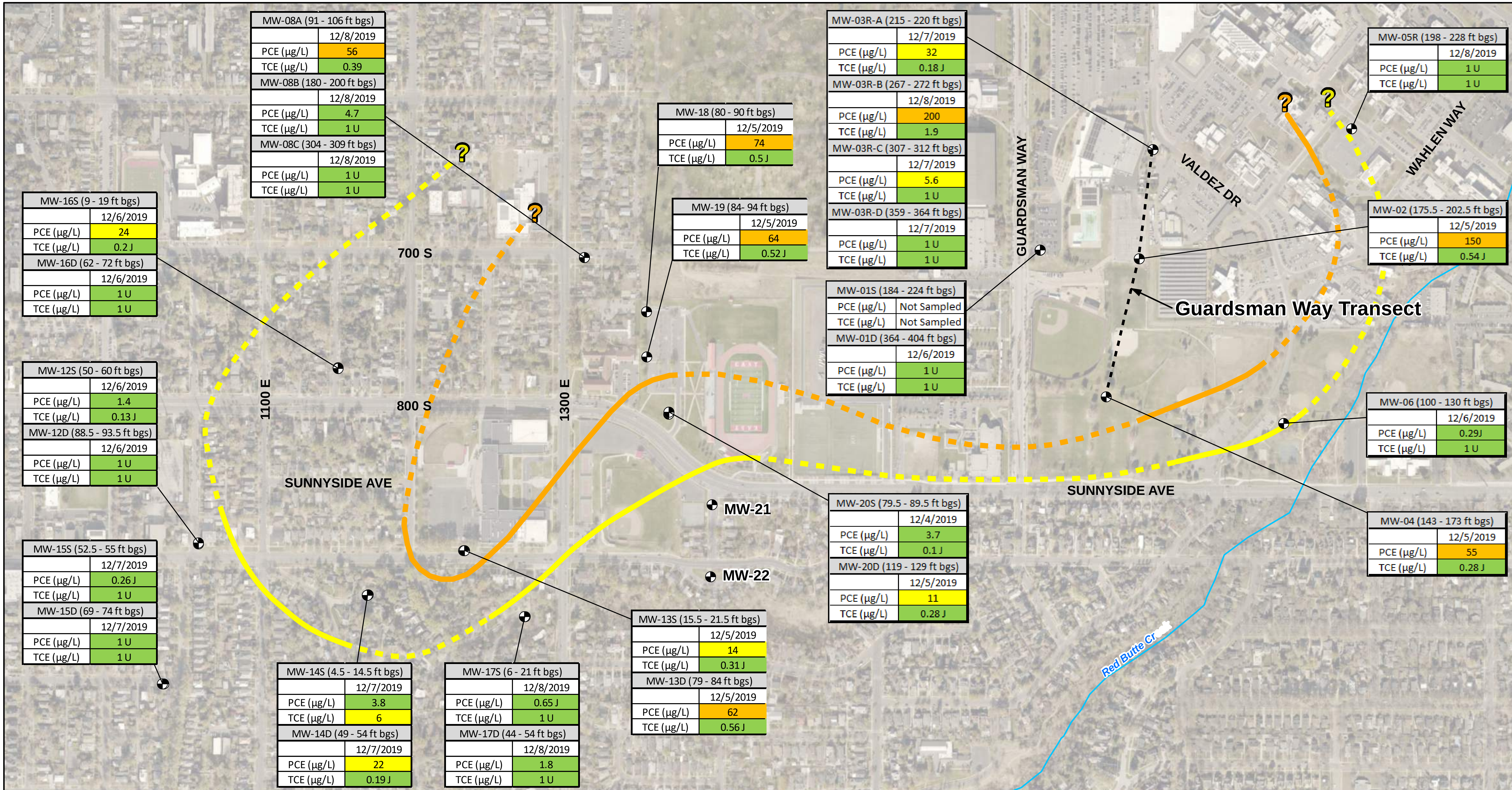
1. Proposed well locations are approximate and may change according to site conditions and access agreements.
2. Water level data from April 2016, as presented in Conceptual Site Model (EA, 2017a).
3. The total depth and screen interval for shallow monitoring well locations will be determined based on the drilling log and identification of "first water." Monitoring wells labeled S/D are clustered 2-inch wells.
4. Monitoring well IDs will be numbered sequentially in order of installation.
5. The total depth, screen interval, and monitoring well type for the proposed deep monitoring well locations will be determined based on the drilling log, natural gamma logging, and push-ahead groundwater sampling.

Source: Phase 1 RIWP (CH2M Hill, Inc. 2018)

FIGURE 2-3
A-A' CROSS SECTION

CDM Smith

Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend
- Monitoring Well
- Monitoring Well Transect Line
- Red Butte Creek

PCE and TCE Concentrations (µg/L)
- = < 5 µg/L
- = 5 - 50 µg/L
- = > 50 µg/L

PCE Contours
- 5 µg/L
- 50 µg/L

Dashed Line - Inferred Extent
? - Extent not Defined

Notes
(1) PCE extent derived from December 2019 analytical results. For wells with multiple depth intervals the highest concentration was selected.

OU = operable unit
PCE = tetrachloroethene
TCE = trichloroethene
µg/L = micrograms per liter
ft bgs = feet below ground surface

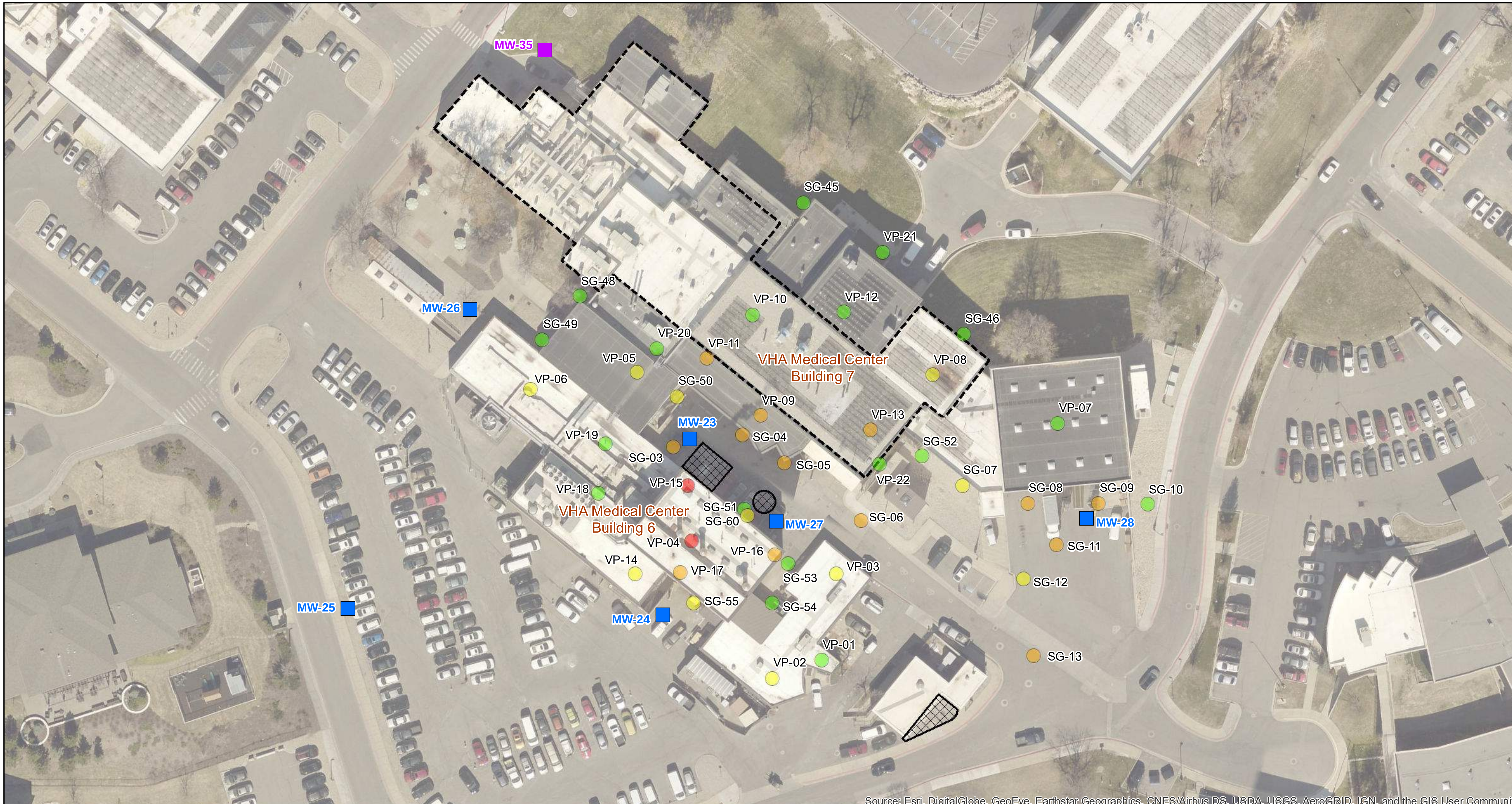
N
0 500 1,000 Feet

FIGURE 3-1
2019 Q4 GROUNDWATER PCE AND TCE RESULTS AND APPROXIMATE EXTENT OF PCE IN GROUNDWATER

CDM Smith

OU1 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\InitialMaps\DSR_2019Q4\Fig3_DSR_PCE_and_TCE_in_GW.mxd WAGNERA 3/5/2020



Boring Location - Phase 1

Proposed Boring Location - Phase 2

PCE Soil Vapor Concentrations < 10% Screening Level

PCE Soil Vapor Concentrations between 10% of Screening Level and Screening Level

PCE Soil Vapor Concentrations > Screening Level

PCE Soil Vapor Concentrations > 10 times Screening Level

Perimeter of Building 7 in 1981

Underground Storage Tank or Foundation

Notes:
SG = soil gas probe
VP = vapor pin. Locations for vapor pins are approximate.
-Color coding based on the maximum of the December 2018 or March 2019 TO-15 / HAPSITE data and July 2019 HAPSITE data for each location. The screening level for PCE in soil gas is 600 µg/m³.

N

0 25 50 Feet

1 inch = 60 feet

CDM Smith

FIGURE 4-1
PROPOSED PHASE 2 INVESTIGATION LOCATIONS - BUILDING 6/7 AREA

OU1 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

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Legend
- Monitoring Well
- Proposed Well Pair
- Boring Location - Phase 1
- Proposed Boring Location - Phase 2
- Red Butte Creek
- Fault Line
- Transect Line

5 µg/L PCE
50 µg/L PCE
Dashed Line - Inferred Extent
? - Extent not Defined

Notes
-MW-33 is planned for installation in Phase 1 but has not been installed to date.

N

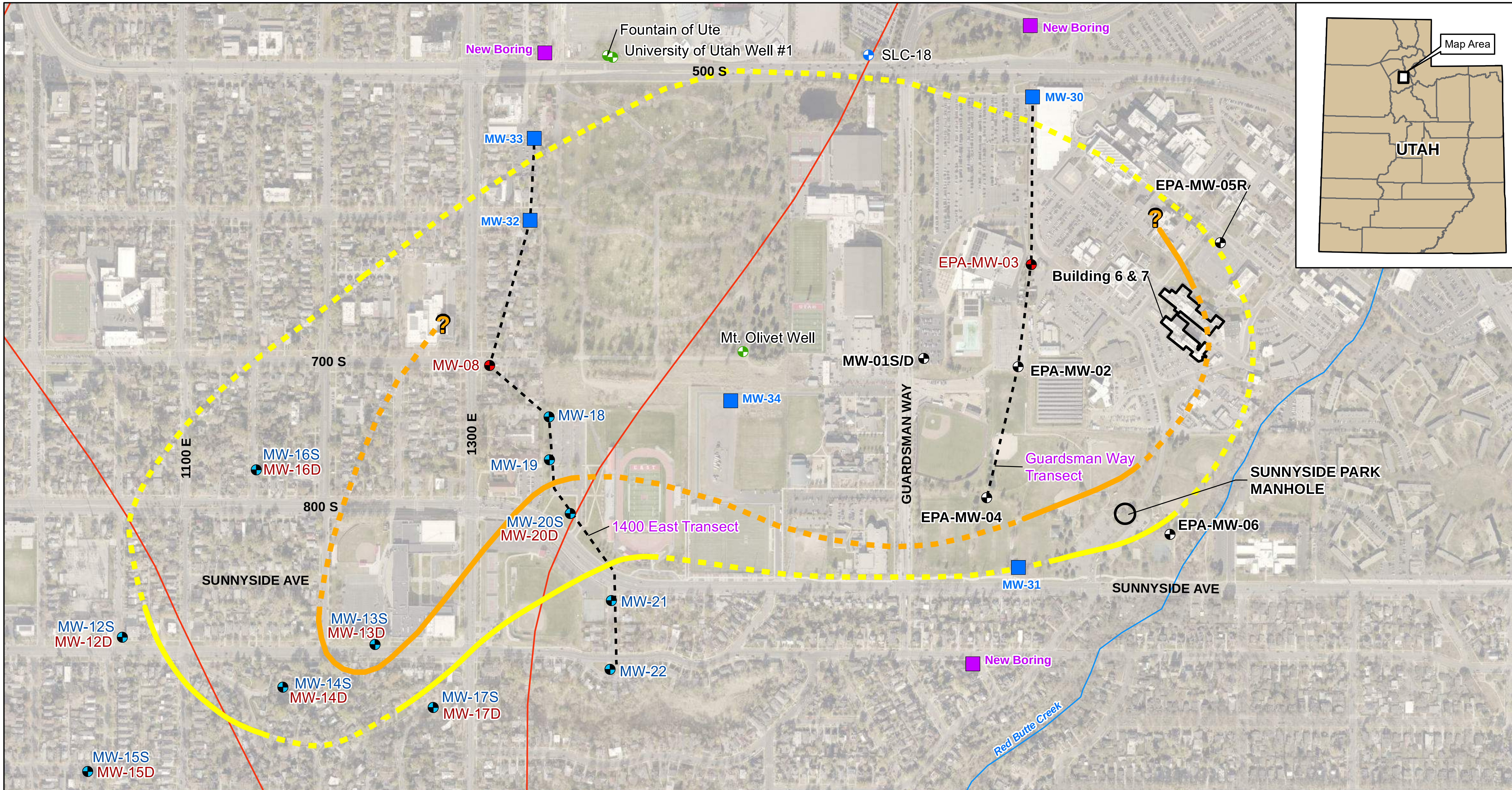
0 500 1,000 Feet
1 inch = 420 feet

FIGURE 4-2
PROPOSED PHASE 2 INVESTIGATION LOCATIONS - EAST SIDE SPRINGS

CDM Smith

OU-1 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2020\RIWP_2020\Fig4-2_Proposed_Borings_West.mxd WAGNERA 8/4/2020



Legend

- Monitoring Well
- Boring Location - Phase 1
- Step-out Boring - Well IDs to be determined
- Red Butte Creek
- Fault Line
- Transect Line
- Deep Monitoring Well
- Shallow Monitoring Well
- 5 µg/L PCE
- 50 µg/L PCE

Dashed Line - Inferred Extent
? - Extent not Defined

Notes
- µg/L = micrograms per liter
- Proposed step-out boring locations will only be installed if Phase 1 borings and wells do not delineate plume boundaries.

N

0 500 1,000 Feet
1 inch = 525 feet

FIGURE 4-3
PROPOSED PLUME DELINEATION
BORINGS - PHASE 2

CDM Smith

OU-1 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2020\RIWP_2020\Fig4-3_Proposed_Plume_Delineation_Borings.mxd WAGNERA 8/4/2020

Appendix A

Field Sampling Plan